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Columbia-North Pacific Region

Comprehensive Framework Study
of Water and Related Lands

APPENDIX XII

WATER QUALITY AND POLLUTION CONTROL

SUBMITTED BY

PACIFIC NORTHWEST RIVER BASINS COMMISSION
1 COLUMBIA RIVER, VANCOUVER, WASHINGTON

DECEMBER 1971

This appendix is one of a series making up the complete Columbia-North Pacific Region Framework Study on water and related lands. The results of the study are contained in the several documents as shown below:

Main Report	Summary Report

Appendices

I.	History of Study	IX.	Irrigation
II.	The Region	X.	Navigation
III.	Legal & Administrative Background	XI.	Municipal & Industrial Water Supply
IV.	Land & Mineral Resources	XII.	Water Quality & Pollution Control
V.	Water Resources	XIII.	Recreation
VI.	Economic Base & Projections	XIV.	Fish & Wildlife
VII.	Flood Control	XV.	Electric Power
VIII.	Land Measures & Watershed Protection	XVI.	Comprehensive Framework Plans

Pacific Northwest River Basins Commission
1 Columbia River
Vancouver, Washington

Water Quality & Pollution Control

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APPENDIX XII

Columbia-North Pacific Region
Comprehensive Framework Study
of Water and Related Lands. Appendix ~~XII~~.
Water Quality and Pollution Control,

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James Sweeney

11 December 1971

12 559p.

Prepared by
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APPENDIX XII
Water Quality & Pollution Control

Prepared under the direction of the
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This appendix to the Columbia-North Pacific Region Framework Report was prepared at field level under the auspices of the Pacific Northwest River Basins Commission. It is subject to review by the interested Federal agencies at the departmental level, by the Governors of the affected States, and by the Water Resources Council prior to its transmittal to the President of the United States for his review and ultimate transmittal to the Congress for its consideration.

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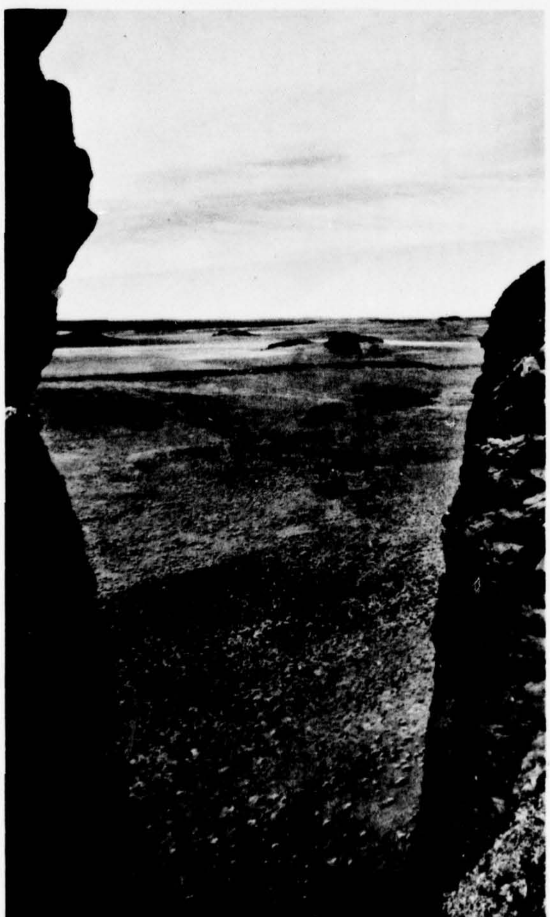


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INTRODUCTION

The Columbia-North Pacific Region covers about 174 million acres in the states of Washington, Oregon, and Idaho; western Montana; and small portions of Wyoming, Utah, and Nevada. In terms of water drainage, it includes the Columbia River Basin, Puget Sound, the coastal drainages of Oregon and Washington and the Oregon portion of the Great Basin. The major physiographic provinces are the Coast Range, Puget Sound-Willamette Valley Trough, Cascade Range, Columbia Plateau, Blue Mountains, Oregon Closed Basin, Snake River Plain, and Northern Rocky Mountains.

The climate of the region is primarily modified continental, with the exception of the strip west of the Cascades, which is relatively warm and humid as a result of the maritime influence. From the crest of the Coast Range, where rainfall exceeds 200 inches, annual precipitation decreases to about 35 inches in the Puget Sound-Willamette Trough, then rises again to 100 inches or more toward the crest of the Cascade Range. About two-thirds of the year's total falls during the October to March period. East of the Cascade Range, precipitation decreases rapidly to 10 inches or less in the valleys and plateaus. The mountain areas have higher total precipitation of 40 to 50 inches--much of it as snow. Two large elevated plateaus, the Snake River Plain and the Columbia Plateau, receive from 10 to 20 inches of precipitation.

West of the Cascade Range, temperatures in the lower areas range from a January average of 36° F (2° C) to a July average of 62° F (17° C). Except in the southern interior valleys, temperatures above 100° F (38° C) are rare. Temperatures below 0° F (-18° C) have occurred, but in the lower valleys temperatures below 10° F (-17° C) are unusual. The average frost-free season is from 200 to 240 days, covering the period from April to November. Mountain areas are cold the year around and have a much shorter growing season. East of the Cascade Range, temperature patterns are quite different. Average January temperatures range from 20° F (-7° C) in the mountains to 32° F (0° C) in the warmest valley areas, and average July temperatures similarly range from 60° F to 76° F (16° to 24° C). At most stations, temperatures well above 100° F (38° C) have been recorded in summer, and temperatures of -30° F (-34° C) are fairly common in winter, with some below -50° F (-46° C) having been recorded. In the mountains and in the Oregon Closed Basin, the frost-free growing season is generally less than 100 days, from mid-June to mid-September. In the

valleys and on the Columbia Plateau, the frost-free season is 140 to 200 days long, from late April to late September.

Almost half of the land area in the region is in forests. Nearly one-third is rangeland; about one-tenth is used for crop or other agricultural land; and less than five percent represents municipal, railroad, highway, and other miscellaneous uses. The important land areas which support the more intensive farm and rangelands and major concentrations of population are the Puget Sound-Willamette lowland, the Yakima Valley, the Columbia Plateau, and the Snake River Plain. There are several small but important valleys such as the Bitterroot, Flathead, and Okanogan.

The economy of the Columbia-North Pacific Region has been largely influenced by the development of natural resources. The most important single category of economic development has been the harvesting of products grown on the land. These products include those from forestry and agriculture. Lumber and wood products, food and kindred products, and paper and allied products constitute the major classes of manufacturing activity. Transportation equipment is also an important activity as a result of the Boeing airplane manufacturing operations. The primary metals industry is the next most important industrial activity.

In 1965, the population of the region was about 5.9 million persons. Nearly two-thirds of the population lived in the area west of the Cascade Mountains, which constitutes less than a fourth of the total land area. Approximately 62 percent of the population resided in 34 major service areas. 1/ The distribution of the population by urban, rural, and rural non-farm classifications has closely followed the national pattern. The trend has generally been an increase in urban, a decrease in rural farm, and an increase in rural non-farm population.

For purposes of the Type 1 Study, the region is divided into 12 subregions delineating major watersheds or groups of watersheds, and in most cases including more than one large stream (figure 1). Many of these subregions are further divided in terms of subbasins and major service areas. Each of the subbasins contains major water developments and warrants special consideration for this study.

In contrast to conditions in many other parts of the Nation, water quality in the Columbia-North Pacific Region is still generally very good, with vast quantities of relatively unpolluted water available. At the same time, however, serious pollution problems do exist in various parts of the region, resulting in deterioration

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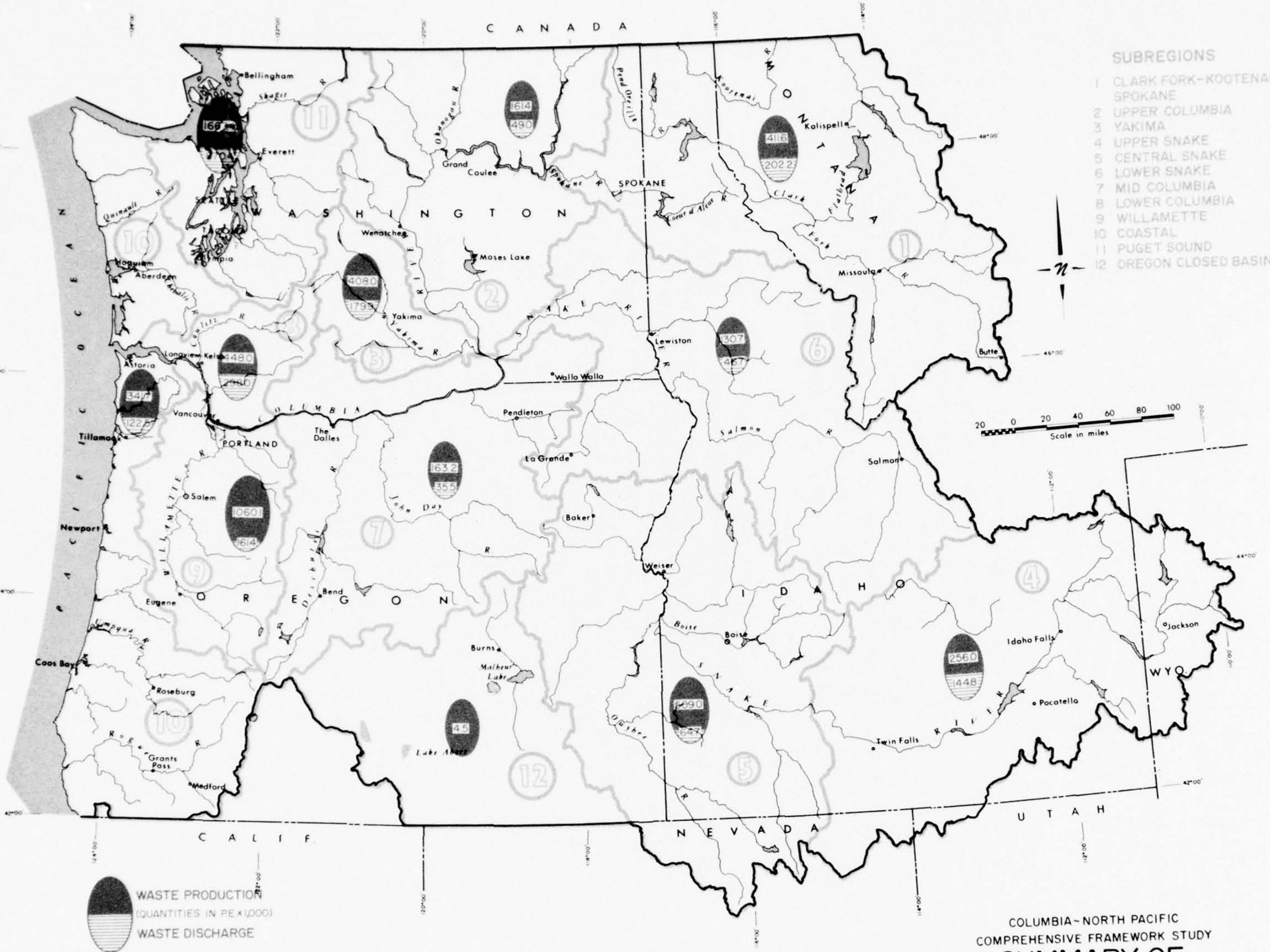
1/ See glossary.

of the quality of water supplies, damage to sport and commercial fisheries, and undesirable public health and aesthetic conditions.

The purpose of this appendix is to present the current status of water quality and pollution control in the Pacific Northwest; to project future water quality management needs; and to discuss the means to satisfy those needs.

Continuing changes in pollution sources and water quality make it impossible to publish a report with the up-to-date information; therefore, it was necessary to establish a base year for the data. The base year of 1965 was used for waste discharge inventories and population discussions. Other sections of the report were updated to 1968 where possible. Due to the necessity for establishing a base year, there are some instances where the dates quoted for implementation of pollution control measures have already passed. Implementation plans have been considered in all projections.

In a report of this type, current conditions can only be used as an indication of general problem areas and as a base upon which to make future projections. The reader is cautioned to consider this limitation when using information contained in this report.



COLUMBIA–NORTH PACIFIC
COMPREHENSIVE FRAMEWORK STUDY

SUMMARY OF PRESENT MUNICIPAL WASTES
C-NP REGION
1970

FIGURE 1

REGIONAL SUMMARY

R E G I O N A L   S U M M A R Y

PRESENT STATUS

Stream Characteristics

Stream characteristics are the key element of any water quality formulation. Because of the relationship of streamflows to water quality, an understanding of surface-water hydrology and streamflow characteristics is fundamental to water quality management. Water quality is a dynamic phenomenon which constantly evolves and is modified in the interaction of a variety of factors. Runoff, seasonal flow variations, and the cycle of drought and flood make up the matrix which is the background of water quality conditions.

Surface-Water Hydrology

The quantity of water available for dilution and assimilation of pollutants is the first item considered relative to the effects of discharged wastes. In general, the water resources of the Pacific Northwest represent one of the Nation's outstanding water supplies and one possessing favorable relationships between yields and withdrawals. The average discharge from the Columbia-North Pacific Region, including 74,000 cfs inflow from Canada, is about 384,000 cfs, or 278 million acre-feet per year for the period 1929-1958.

In spite of the apparent large total supply, water is not always available where and when it is needed to meet requirements. Extreme variations occur in the areal distribution of annual runoff. West of the Cascade Range, precipitation generates an average annual runoff that exceeds 40 inches. The major part of the runoff occurs in winter and is closely related to precipitation. In the eastern portion of the region, most precipitation occurs in the form of snow, and streamflows are maximum during the spring and early summer when the snow melts.

Studies to predict recurrence frequencies of critical low flows are based upon recorded and correlated flows adjusted to reflect expected reservoir regulation in 1970. Design criteria for determining the need and value of flow regulation for water quality control include a probable drought recurrence interval of one in ten years. From the standpoint of waste discharge control, the low-flow months of July, August, September, and October are the most important. In most of the region, August is the critical month.

Impoundments and Stream Regulation

There are more than 160 reservoirs in the region, each with an active storage capacity greater than 5,000 acre-feet. The total active storage capacity is approximately 40 million acre-feet. The purposes for which this storage has been allocated are municipal, power, flood control, recreation, irrigation, and fish and wildlife conservation. Almost no storage is authorized for water quality control, although incidental benefits result from releases for other purposes.

When a free-flowing stream is impounded, the modification of its physical and chemical properties and biological populations results in changes in the quality of water. The changes in quality that occur during storage can be beneficial or detrimental to water within the reservoir and downstream. Beneficial effects resulting from reduced stream velocities include settling of suspended materials and increased time-of-travel, permitting die-away of bacteria. This situation seems to occur in Brownlee Reservoir on the Snake River. Another beneficial aspect is the lower downstream temperatures that occur from low-level releases of cool water. A detrimental effect is thermal stratification, preventing reaeration of lower levels as organics settle out, decay, and deplete bottom dissolved oxygen concentrations. Releases from low-level outlets can reduce downstream dissolved oxygen concentrations. Releasing water over spillways at dams may cause nitrogen supersaturation in the water resulting in a condition toxic to migrating fish. The stimulation of algal growth is another adverse effect of impoundments. Warm surface temperatures and increased depth of light penetration through the clear waters of reservoirs contribute to prolific algal growths, particularly when abundant quantities of nutrients are available--such as nitrogen and phosphorus. These biological organisms create nuisance conditions and affect the dissolved oxygen (DO) concentration through their photosynthetic activity and decomposition. Algal problems are most prevalent in the many reservoirs on the Snake River; in Fern Ridge, Cottage Grove, and Lookout Point Reservoirs in the Willamette Subregion; and in Moses Lake in the Upper Columbia Subregion.

The extensive level of development that has been imposed upon the waters of the region makes the effects of impoundments an important feature of the water quality situation. However, examination of impoundments with regard to quality has been very limited.

Stream management is an important factor affecting water quality, since quality is related to the amount of water available. Occurrence of low flows critical to quality control is in part a result of the management regimen of the region's waters. Low flows are frequently the result of withholding water to build up storage

or the actual diversion of a significant part of a stream for irrigation. Existing reservoirs in the region do not have storage specifically allocated to water quality control; however, streamflow provided for other purposes is often of considerable assistance in improving water quality.

Pollution Sources

At the present time, municipalities and industries in the Columbia-North Pacific Region produce wastes equivalent to those from a population of 40.8 million persons. Municipal wastes total about 5.53 million PE, and industrial wastes equal those from an additional population of about 35.28 million people. Of the total wastes generated in the region, 64.4 percent are from the pulp and paper industry, 20.4 percent from the food-processing industry, 13.6 percent from municipal sources, and 1.1 percent from the lumber and wood products industries. The remaining 0.5 percent is from other miscellaneous industries.

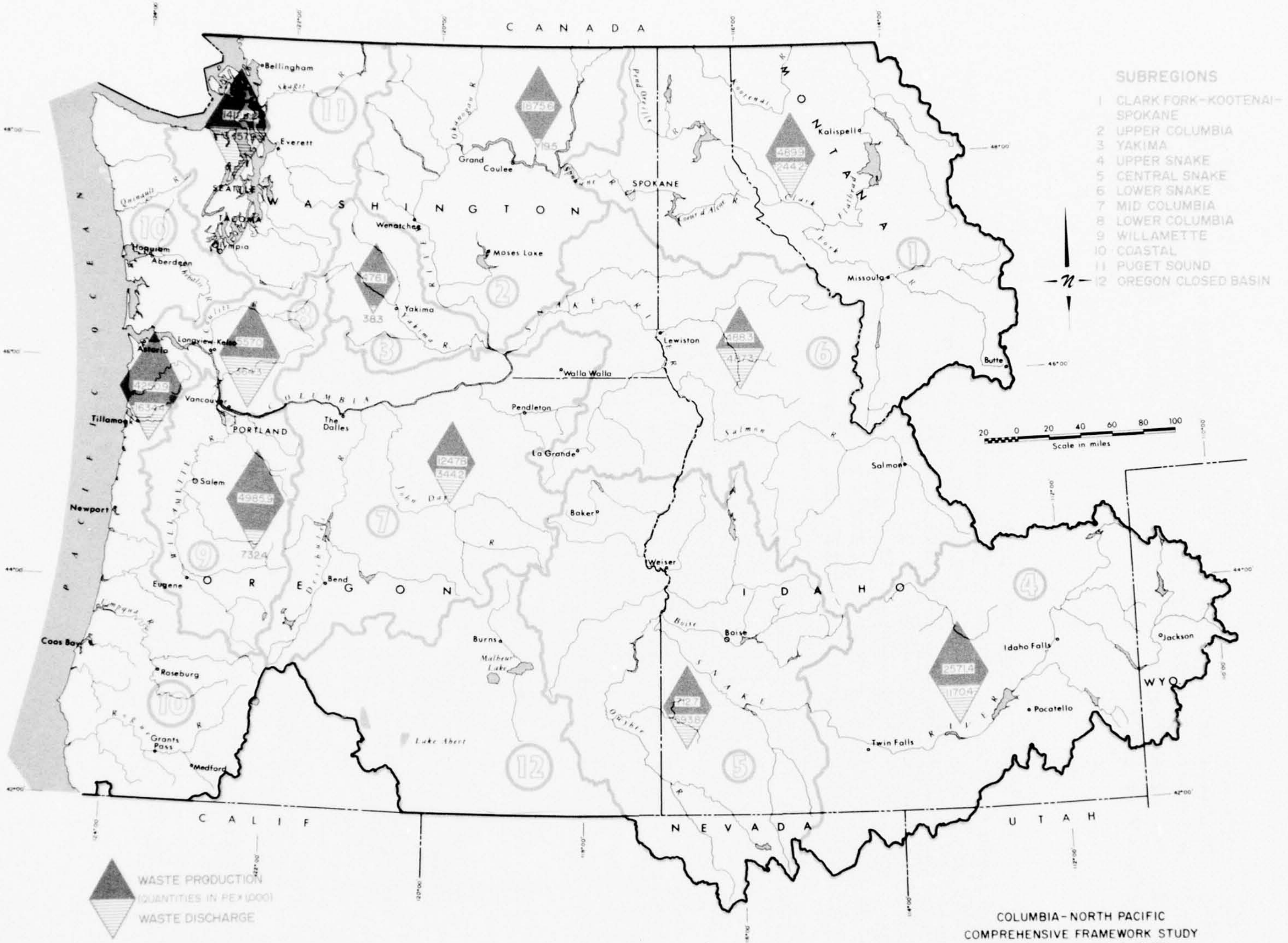
Table 1 summarizes municipal and industrial waste treatment sources and treatment practices in the region. Figures 1 and 2 present a graphical summary of municipal and industrial waste production and discharge for each subregion. Population equivalents (PE) refer only to oxidizable organic material in the waste and do not take into account other pollution characteristics that may be of equal or greater importance.

Table 1 - Inventory of Municipal and Industrial Wastes, Columbia-North Pacific Region1/

	Number of Plants	Population Served	Population Equivalents Produced	Discharged	Removal Efficiency %
Present Municipal Waste Treatment					
Primary	161	1,774,683	2,596,175	1,570,805	40
Secondary	195	997,015	2,415,820	490,770	80
Lagoons	132	288,090	397,010	77,615	81
Other	77	107,931	125,760	97,530	23
Region Total	565	3,167,719	5,534,765	2,236,720	60
Present Industrial Waste Treatment					
Pulp and Paper	47		26,304,540	19,383,550	26
Food Products	253		8,309,240	2,981,385	64
Lumber and Wood Products	90		437,920	154,500	65
Miscellaneous	87		234,815	101,280	57
Region Total	477		35,286,515	22,620,715	36

1/ FWPCA inventory of Municipal and Industrial Wastes, 1965
Inventory for Subregions 9 and 11 from respective Type 2 Study, 1970

Waste treatment and other means of waste reduction decrease the total waste strength by about 37.7 percent, so that 25.85 million population equivalents are released to waterways. Municipalities accomplish an average removal efficiency of 60 percent, resulting in a waste loading of 2.23 million PE. Industries remove only 36 percent of their average waste loads so that 22.62



COLUMBIA-NORTH PACIFIC
COMPREHENSIVE FRAMEWORK STUDY

SUMMARY OF PRESENT INDUSTRIAL WASTES

C-NP REGION

1970

FIGURE 2

million PE are discharged. The pulp and paper and food-processing industries account for 19.38 and 2.98 million population equivalents, respectively.

Irrigation and land-use practices are important sources of inorganic loadings and are also responsible for relatively small organic waste loadings. The magnitude of these wastes cannot be readily identified. The rural population and agricultural animals are sources of organic wastes. The actual quantities of wastes reaching waterways are not considered to be large, but they can lead to localized pollution problems. Natural sources, navigation and dredging, and recreation are relatively minor pollution sources.

Municipal

Municipal sewage is the water-carried waste from residential, public, commercial, and minor industrial sources discharged into a collection system for transport to a central treatment and/or discharge point. Amounts and strength of residential wastes are basically related to the population served by sewage collection facilities, but additional loads may be discharged to the system by commercial and industrial establishments. These wastes cause the total load to vary from a norm and may also cause significant seasonal fluctuation. Quantity and strength of wastes are influenced by infiltration of ground water into sanitary sewers and storm-water inflow to combined systems, both of which may cause bypassing of raw wastes directly to the river during periods of excessive sewer flow.

In 1965 there were 565 municipal sewer systems serving a population of 3,167,719 in the Columbia-North Pacific Region. This represents about 53 percent of the region's total population. Approximately 86 percent, or 485, of the waste collection systems have some type of conventional treatment before discharge, including 195 with secondary treatment, 161 with primary treatment, and 132 with lagoons or oxidation ponds (table 1).

The total municipal waste strength generated, including wastes from a number of food-processing and other industries discharging to municipal systems, is equivalent to that from a population of 5,534,765 persons. Treatment reduces the organic oxygen-demanding waste load by 60 percent, so that approximately 2,236,720 population equivalents are released to region waterways. The major effects of municipal wastes have been bacterial contamination and oxygen depression in the streams. Other adverse influences include buildup of excessive nutrients, color, toxicants, and solids.

Figure 1 presents a graphic summary of municipal waste production and discharge for each subregion. As could be expected, the municipal waste production is closely related to population. Only

in the Upper Snake, Central Snake, Willamette, and Lower Columbia Subregions do waste strengths differ considerably from the number of people served by municipal sewers. In the Upper Snake, Central Snake, and Willamette Subregions, this condition exists because a number of food-processing and other industries discharge waste waters to municipal sewer systems. In the Lower Columbia this results from the fact that the city of Portland in the Willamette Subregion discharges to the Lower Columbia.

The subregions (8-11) west of the Cascade Range produce about 3.5 million population equivalents, or 63.6 percent of the regional municipal total; and discharge about 1.6 million population equivalents, or 72.7 percent of the regional total, to the receiving streams. The heavily populated Willamette and Puget Sound Subregions generate about 2.6 million PE, or 47.2 percent of the regional total. The Puget Sound Subregion discharges 33.6 percent of the regional waste load, or slightly more than 740,000 PE. The Lower Columbia (including the city of Portland) discharges nearly 370,000 PE.

East of the Cascade Range, the largest municipal waste production is in the Clark Fork-Kootenai-Spokane, Central Snake, and Upper Snake Subregions, which generate about 411,580, 509,000, and 256,000 PE, respectively. The largest municipal waste discharges occur in the Upper Snake and Clark Fork-Kootenai-Spokane Subregions--144,800 and 160,540 PE, respectively.

The Central Snake Subregion exhibits the highest waste treatment efficiencies, removing an average of about 87 percent of the oxygen-demanding waste load. The lowest levels of waste treatment are in the Lower Columbia, Upper Snake, and Puget Sound Subregions, with average efficiencies of 34, 42, and 48 percent, respectively. All other subregions accomplish average reductions between 63 and 78 percent, except the Oregon Closed Basin. The Oregon Closed Basin discharges all of their wastes to land; however, due to climate conditions, none of the wastes reach surface waters.

Industrial

Industrial wastes are those spent process waters associated with industrial operations which are discharged separately and not in combination with municipal wastes. Pollutional characteristics of industrial wastes are so varied that it is not possible to establish a quantitative measure of industrial waste discharge that covers all factors, although partial evaluation can be made with respect to specific characteristics. Waste discharges from industries may contain: organic matter, toxic materials, suspended and dissolved solids, nutrients, oil and grease, color, taste, odor, acidity or alkalinity, and heat. For purposes of the Framework

Study, industrial waste loadings will be given in terms of Biochemical Oxygen Demand (BOD) by comparison with domestic sewage on the basis of population equivalents.

The total industrial waste generation in the Columbia-North Pacific Region is equivalent to that from a population of 35.3 million persons. About 36.0 percent of the oxygen-demanding industrial wastes are removed by waste treatment and other means of waste reduction, so that 22.6 million population equivalents actually reach region waterways.

The pulp and paper and food-processing industries are the major sources of organic wastes, producing 26.3 and 8.3 million population equivalents, respectively. The lumber and wood products and miscellaneous industries generate organic wastes of about 437,920 and 234,815 PE, respectively. Inorganic wastes are principally from primary metals and mining operations and chemical plants.

The pulp and paper industry generally provides only minimal treatment, which reduces the waste load by about one-quarter. This results in an organic loading of 19.4 million population equivalents to region waterways. Reliance is generally placed upon in-plant solids reduction facilities with, however, an emerging trend toward provision of facilities equivalent to primary treatment for removal of the suspended solids loads carried by mill effluents. Storage of wastes during low streamflow periods for release during high water periods is also a common practice. Spent sulfite liquor discharged as a waste product in the sulfite pulping process is the strongest pollutional waste developed and discharged in significant quantities in the region. The sulfite waste liquors (SWL) are high in biochemical oxygen demand, are toxic, and impart color. Barker wastes and white waters from pulp drying and paper conversion carry high concentrations of settleable suspended solids. The wood fiber in the wastes settles and forms sludge beds in streams. In addition, pulp and paper wastes are the principal source of nutrients and fibrous materials required for *Sphaerotilus* growths, the filamentous slime that clogs commercial fishing gear.

The food-processing industry achieves a treatment efficiency of about 64.1 percent, resulting in an organic waste loading of about 3.0 million population equivalents. The peak of the vegetable- and fruit-processing season usually occurs during a period when climatic conditions are favorable for lagoon or land disposal. Potato and sugar beet wastes usually receive primary treatment; however, the characteristics of the wastes and seasonal operation of such plants during cold-weather periods make efficient operation of secondary treatment methods, lagooning, or land disposal difficult. Effluent from food processors includes nutrients which can stimulate algal blooms, settleable solids, color, and organic matter of high biochemical oxygen demand.

The lumber and wood products industry discharges an oxygen-demanding waste load equivalent to that from a population of 154,500 persons. However, for the industry, oxygen-demanding waste characteristics are of only minor importance. Plants utilizing hydraulic barkers can contribute suspended solids which damage aesthetic conditions and serve as a base for attachment of slimes. Log ponds serve as a source of suspended materials and complex organic compounds which may generate undesirable problems, such as color and odor. Phenolic glue wastes from plywood mills are highly toxic to aquatic organisms.

The primary metals, mining, and chemical industries are the major sources of inorganic waste discharges in the region. In general, little data are available concerning wastes from primary metals plants. However, it is known that wastes from aluminum refineries may contain objectionable quantities of oil, flourides, and cyanides and may be of a high temperature. The mining industry, including gravel washing, is an important source of turbidity and sedimentation. In addition, heavy metals often discharged with mine washings are extremely toxic to all forms of life and have caused biological sterilization in a number of region streams. Wastes from chemical industries generally receive adequate treatment. However, accidental spills of toxic materials and the discharge of wastes from phosphate refining have caused serious problems.

Figure 2 presents a graphic summary of industrial waste production and discharge for each subregion. The Puget Sound, Willamette, Coastal, and Lower Columbia Subregions are the largest sources of industrial wastes. With the exception of the Willamette, a very small level of waste reduction is generally maintained. These subregions, all west of the Cascades, produce 76.8 percent and discharge 86.7 percent of the total regional organic waste loading. The pulp and paper industry is responsible for over 90 percent of the waste loading in each of these subregions. In the Puget Sound, Coastal, and Lower Columbia Subregions, the seafood, fruit and vegetable, and dairy-processing industries also discharge significant quantities of wastes. The lumber and wood products industry is also an important waste source in the Willamette, Coastal, and Puget Sound Subregions.

East of the Cascade Range, the food-processing industry is the largest source of industrial wastes, and the pulp and paper industry ranks second. The Upper Snake, Central Snake, Upper Columbia, Mid Columbia, and Yakima Subregions are the most important areas of food-processing waste production. In the Yakima and Upper Columbia, a high level of waste treatment is maintained, and in the remaining areas waste treatment practices are generally in need of improvement. In the Upper and Central Snake Subregions,

wastes are primarily the result of potato processing and sugar refining. In addition, there are a number of important vegetable and dairy processing plants that contribute wastes. The largest portion of the waste loading in the Yakima and Mid Columbia is from fruit and vegetable processing. In the Upper Columbia, fruit and vegetable processing, including the processing of potatoes and sugar beets, is the major waste source. The production and manufacture of pulp and paper account for large waste loadings in the Clark Fork-Kootenai-Spokane, Lower Snake, and Mid Columbia Subregions. In general, waste treatment for the pulp and paper industry is in need of improvement.

Although not reflected in organic loadings, mining wastes contribute to pollution in the Idaho and Montana portions of the Clark Fork-Kootenai-Spokane Subregion. Also, in the Upper Snake, inorganic phosphate wastes from chemical plants are a significant pollution source. The National Reactor Testing Station discharges low-level radioactive wastes into seepage pits, lagoons, and disposal wells. The effluent eventually reaches the Snake River Plain Aquifer. Similar disposal practices are also employed at the Hanford Works and, in addition, waste heat is discharged to the Columbia River.

Table 2 - Summary of Population Served by Individual Waste Disposal Systems, Columbia-North Pacific Region 1/

Subregion	Population Served Thousands	Percent Subregion Population	Percent Region Population
1. Clark Fork-Kootenai-Spokane	246.7	41.2	4.1
2. Upper Columbia	115.3	46.1	1.9
3. Yakima	86.4	46.8	1.6
4. Upper Snake	165.9	55.0	2.8
5. Central Snake	121.3	45.2	2.0
6. Lower Snake	72.0	44.0	1.2
7. Mid-Columbia	98.1	46.7	1.7
8. Lower Columbia	137.5	62.4	2.3
9. Willamette	602.2	45.0	10.1
10. Coastal	198.4	46.6	3.3
11. Puget Sound	930.9	47.2	15.7
12. Oregon Closed Basin	8.8	66.2	0.1
Total	2,783.5		46.8

1/ Derived as a residual from FWPCA Municipal and Industrial Waste Inventory, 1965, and from Type 2 Studies for Subregion 9 and 11, 1970.

Rural-Domestic

Approximately 2.78 million persons, or 46.8 percent of the region's population, are not connected to municipal waste treatment facilities. Table 2 summarizes by subregion the population and percent of subregion and region population served by individual sewage disposal systems.

In general, septic tanks and some type of subsurface, drainage are used for waste disposal by the rural population. The actual waste load reaching waterways is not known; however, it is not considered to be large. It should be emphasized that connection to an adequate public sewerage system is a more satisfactory method of sewage disposal. Every effort should be made, therefore, to secure public sewer extensions. Where connection to a public sewer is not feasible, and when a considerable number of residences are to be served, consideration should be given to the construction of a community sewerage system and treatment plant.

Irrigation

The largest use of water in the Columbia-North Pacific Region is for irrigation. A total of about 7.34 million acres are irrigated requiring an annual diversion of 33.1 million acre-feet of water. Approximately 90 percent of the land is irrigated with water from surface supplies and the remainder from underground supplies. About 17.7 million acre-feet return to streams as irrigation return flows.

The major areas of large, concentrated irrigation development have been in the Columbia Basin Project of the Upper Columbia, along the main stem Snake and Henrys Fork of the Upper Snake; in the Payette, Boise, and Snake River Valleys of the Central Snake; and in the lower Yakima Valley of the Yakima Subregion. The Willamette, Mid Columbia, Clark Fork-Kootenai-Spokane, Lower Snake and Oregon Closed Basin Subregions have important irrigated areas, but have been developed to a lesser degree.

Irrigation diversions and return flows are significant pollution sources in several areas of the region. Irrigation withdrawals contribute to water quality degradation for at least two reasons: they deplete streamflow and reduce its dilution and assimilative capacity; and they can cause significant increases in sediment, mineral, and nutrient loads. There is a great variation in the effect of irrigation return flows on water quality. Size of irrigated areas, application rates and reuse factors, soil properties, topography, temperature, and irrigation methods all influence water quality.

The major quality changes of water draining from an irrigated area can be alterations in chemical composition and increases in the total amount of dissolved solids, temperature, color, and turbidity. In the Yakima Subregion, studies have indicated that the return flows may carry up to five times the phosphate, 20 times the sulfate, and 30 times the nitrate concentration of the applied water. The amounts of dissolved solids added to the receiving stream by irrigation are computed to be 0.24 and 0.325 (2) ton of dissolved solids per year per irrigated acre for the Yakima and Snake River basins, respectively. Uncontrolled passage of water over fields tends to move solids gradually and, when this process continues, natural channels are formed and the rate of erosion is progressively accelerated. While not completely controllable, erosion due to irrigation can be minimized by careful application methods and by adequate water conveyance arrangements. Temperature can be affected either beneficially or adversely by irrigation practices. In general, water applied to ground in summer tends to be warmer than subsurface soils; irrigation returns in the form of seepage, therefore, tend to be cooler than receiving waters. However, surface runoff is affected by solar radiation and ambient air temperatures so surface irrigation returns tend to increase the temperature of receiving water.

The method of applying irrigation to the land water affects the quality of the return flow water. In general, the more efficiently the water is applied, the less deleterious are the effects of irrigation returns on quality. Use of excess water promotes excessive leaching, increases erosion, facilitates flushing of organics and nutrients, and lessens the volume of water available in the waterways. Wild flooding is the least efficient method of irrigation from the standpoint of water quality control. Even where soils are stabilized by well rooted pasture grasses, wild flooding of fields can result in erosion and transport of suspended and dissolved materials. This type of irrigation is not common to the region, however; a few small areas in the Upper Columbia and Upper Snake Subregions rely upon this method. Ridge and furrow and corrugation irrigation are the most extensively practiced irrigation procedures. With the exception of the subregions west of the Cascades and the Upper Columbia Subregion, 80 percent of the land is irrigated by these methods. While less wasteful than wild flooding, these methods generally result in surface runoff with attendant erosion and high temperatures. Sprinkler methods of irrigation, used extensively in the Willamette, Puget Sound, and Upper Columbia Subregions, are being increasingly adopted in the region. This method tends to minimize leaching, erosion, and waste of water.

Other Land Use

Effects of land-use practices on water quality vary according to the pattern of uses, location, time of year, and control procedures. Distinguishing the water quality impacts of human use of land from natural occurrences is difficult, but in the Columbia-North Pacific Region, where extensive use of land for agriculture and for logging is a major facet of the economy, the influence of uncontrolled land runoff constitutes a major influence on water quality.

The production and transport of sediment are the most significant quality impairments resulting from land use in the region. Generalized sediment yields for the region range from 0.02 to 4.0 acre-feet per square mile per year. High concentrations of sediment naturally occur during periods of high precipitation or snowmelt and are carried by floodflows. Various activities on forest lands contribute to soil disturbance. Road construction is perhaps the most important, but logging operations and fire may also have serious effects. On rangelands, too heavy grazing use removes the plant cover and leaves the soil more susceptible to accelerated erosion. On agricultural lands, improper land uses and management are the principal factors in rapid runoff and high rates of soil loss, leading to plugged channels, meandering and bank cutting, and increased flood overflow as well as damages to water quality. Construction of roads, railroads, dams, power transmission lines, and pipelines may also seriously disturb the soil.

Numerous chemicals used in fertilizer and in pest control sprays and dust, or dissolved in drainage water from farmsteads and feedlots, may adversely affect water quality. Chemical sprays are also used over wide areas of forest and range. They may consist of insecticides or fungicides, weed killers, or fire retardants. Large quantities of herbicides, fungicides, and insecticides are applied annually to agricultural, range, and forest lands. Careful use, combined with the ability of the soil to act as a filter, has generally prevented damaging concentrations from reaching the waterways. A hazard is present, however, when toxicants are handled by individuals without proper training. These chemicals may be toxic, but in other instances may add nutrients that cause undesirable aquatic growths in receiving waters. The exact nature of the nutrient balance which will produce algal blooms is not known; however, nitrogen and phosphorus appear to be significant factors in stimulating excessive growths. Chemical fertilizers containing large amounts of nitrogen and phosphorus added to the soils of the region each year create a potential hazard of increasing nutrient loads in drainage waters.

The logging practice of clear-cutting in the Douglas fir forests west of the Cascade Range can cause temporary increases of one to eight degrees F in stream temperature of local watersheds until sufficient vegetative cover is restored to provide stream shade. The temperature increase affects stream ecology and fish habitat, oxygen-carrying capacity of the water, and municipal and industrial use of the water. However, these increases have had little effect on temperatures of major streams in the region.

Addition of materials other than sediment and natural organic debris to streams is a common consequence of land development and use. Urban development is increasing at a rapid pace, and more of the lands will be used for this purpose. A phase of the development is to cover the bare, uprooted subsoil with green grass and shrubbery as quickly as possible. Fertilizers and water are necessary ingredients for fast and uniform plant growth in the sterile soils. When plant nutrients are improperly applied with excessive amounts of water, large portions are washed down the storm drains into the surface waters.

In the established urban areas, the use of insecticides, herbicides, and fertilizers is continued, and they are generally applied by the inexperienced resident. Runoff from hard rains, particularly after a long dry period, flushes the landscape and streets, carrying large quantities of the accumulated chemicals and other debris to the streams, with serious and sometimes prolonged toxic effects in the streams.

Agricultural Animals

Agricultural animal wastes represent a pollution problem in several areas of the Columbia-North Pacific Region. Concentrations of large numbers of animals in limited space such as feedlots and dairies provide opportunities for brief, intense point waste loadings that have high pollutional capabilities. Problems of bacterial contamination and organic pollution have usually been traced to improper discharge of liquid or solid wastes from large poultry houses or concentrations of cattle, such as drainage from dairies and feedlots. Studies have shown that when there is a light rain after a protracted dry period, the flushing effect of the rain on a grazing area can cause a marked rise in bacterial and biochemical oxygen demand in the streams.

The impact of agricultural animal wastes on water quality is difficult to determine. Assuming an animal to human oxygen-demanding waste ratio of 6.4 to 1 for cattle, 0.57 to 1 for sheep, and 0.32 to 1 for chickens, a potential waste production equivalent to that from 35 million persons exists. Because animal populations are diffused throughout the region, and since wastes are deposited on land, the figure attributed to them is not meaningful.

assuming a 95 percent reduction by land disposal, the magnitude of the residual load from animal wastes is 1.75 million population equivalents.

Although the animal population is generally diffused throughout the region, concentrations occur in the Upper Snake, Central Snake, Yakima, Mid Columbia, and Upper Columbia Subregions. In these areas, feedlots which accommodate one thousand or more animals at a time are common. It is also common practice to locate feedlots along streambanks, usually without minimal control afforded by fencing animals from the water. Under these conditions, heavy oxygen demands, bacterial populations, high levels of nutrients, and solids are flushed directly into streams from a rain or washing. On occasion, feedlots have been the source of nitrate, nitrite, and bacterial contamination of shallow ground-water supplies.

Unfortunately, methods to control agricultural animal pollutants are not highly developed. Very little quantitative information exists with respect to effects of animal waste drainages on water quality; and the applicability of control methods and costs associated with them are largely undetermined. The pollutional impact of farm animals, particularly with respect to bacterial concentrations, is assumed to be very significant.

Recreation

Recreation of one type or another is continuous at some locations. Developed and organized recreational installations have sanitary facilities designed to protect the public and the adjacent waters. Pit privies or central facilities discharging to septic tanks and tile fields are the most common means of waste disposal. Increased usage of a park area is frequently followed by construction of improved sanitary facilities.

Sanitary waste facilities are usually deficient at improvised recreation sites such as many small boat landings, water skiing areas, and pleasure- and houseboats. The load, organic and bacterial, from these sources has not been identified numerically, but its importance has been recognized. Unless facilities for collection and pickup of litter and garbage are made available, the waste may find its way to the watercourses.

Regulations governing installation of sanitary facilities are generally adequate, but are difficult to enforce because of the many improvised recreation sites. Some principal research activities are oriented towards improvement of disposal facilities for small recreation areas, pleasure craft, and houseboats.

Navigation and Dredging

Navigation has little effect on water quality in the Columbia-North Pacific Region when all vessels meet present sanitation requirements. However, occasionally large ships discharge untreated sewage to waterways. Accidental spills and bilge pumping are sometimes significant pollution sources. In 1967, there were 33 cases of reported oil spils in the region, and in early 1968 serious spills occurred in Portland Harbor and near the mouth of the Columbia River. Such accidents adversely affect fish and awuatic organisms as well as resulting in property damage.

The dredging of materials from navigation channels and dock facilities often causes turbidity. When bottom materials are high in organics, as they are near pulp and paper mill outfalls, oxygen depressions are also experienced. Dredging materials are sometimes redeposited in other areas, creating similar problems. However, a policy of depositing organic dredging materials on land is generally practiced.

The waters of the region are intensively used for transporting and storing logs. The pollutional effect of this practice cannot be fully quantified but is currently under study at the FWQA Pacific Northwest Water Laboratory.

Natural Sources

In addition to the effects discussed resulting from the exploitation of the water and related land resources, water quality is also affected by certain natural processes.

Glacial scour puts a heavy load of "rock flour," or fine abrasive sediment, into many streams of the Northwest. This results in high turbidity during the summer season of low flow and high demand for water.

Landslides caused by earthquakes or by unstable soil and rock formations heavily lubricated by ground water in abnormally wet seasons or undermined by streambank cutting may discharge huge quantities of soil and rock and organic debris into streams all at once. Undermining and caving of stream channel banks are a form of erosion that contributes significantly to stream sediment loads and turbidity.

On forest and rangelands, the tannin and humic acid complex solutes leach from decomposing natural organic litter, such as leaves, and from logging slash accumulations in watercourses. The tannins and humates can discolor streams and create taste and odor problems; they can also cause septic conditions from excessive oxygen demand.

Forest fires have important effects on water quality. After fires, ashes blown or washed from the burned areas can add significantly to the dissolved solids load of streams and may reduce the quality and usefulness of the water. Major effects usually are noticed only in the first wet season following a burn, but in places where there have been hard burns and sharp changes in soil chemistry, changes in chemical quality may endure two to three seasons. The pH is usually raised; water that is normally neutral or slightly acid may become slightly alkaline. Potassium and phosphorous ions show greatly increased availability in burned forest soils, and it is reasonable to expect similar increases in water draining such soils. With the vegetative cover removed, water temperatures are higher from solar radiation. The warm water, sunlight, and the added nutrients will stimulate algal growths.

Waters that carry high loads of inorganic salts dissolved from rock strata can also lead to pollution situations. A part of the nutrient problem that occurs in the Snake River results from the water passing through phosphorus-bearing earths.

Water Quality

Criteria are a scientific requirement on which a decision or judgment may be based concerning the suitability of water quality to support a designated use. Quality characteristics of a physical, chemical, or biological nature demanded by aquatic life, industrial process, or other use, are requirements or criteria. Determining water quality criteria for various water uses is an important step in solving water pollution problems. Along with vigorous implementation programs, it is a necessary step in achieving water quality management on a scientific basis.

Because of the fishery, water supply, and recreation uses all have extremely rigorous water quality requirements, it is assumed that pollution control directed to serve these needs will more than meet the requirements for other uses. The criteria are not identical in all state water quality standards, but are very similar and compatible.

Dissolved oxygen is the most frequently discussed quality parameter and is quite indicative of general conditions in a body of water. Low dissolved oxygen content indicates that organic and chemical matter is present in sufficient quantity to exert a greater demand for oxygen than can be replaced by the natural reoxygenation capability of the water body. Concentrations of dissolved oxygen greater than 100 percent of saturation are indicative of either recent violent physical reoxygenation at increased pressures or photosynthetic oxygen production by algae. The latter may cause great diurnal fluctuation of dissolved oxygen concentrations.

A dissolved oxygen concentration near saturation with very little diurnal fluctuation is generally the most desirable. The solubility of oxygen in water decreases as the temperature of the water is raised. At sea level and 32° F (0° C), saturation is approximately 14 mg/l; while at 68° F (20° C), 9 mg/l is 100 percent saturation.

The requirement of the salmonid fishery governs the necessary level of dissolved oxygen for most watercourses. Because of the very narrow environmental tolerances of salmonid fish, a dissolved oxygen level very near saturation is essential for spawning, and protracted depressions of dissolved oxygen below 5 mg/l are believed to inhibit migration. A dissolved oxygen concentration of at least 7 mg/l is considered a prerequisite for maintaining a suitable environment for trout and juvenile salmon. Hardier warm-water game fish, however, may subsist satisfactorily in waters with a dissolved oxygen content of 5 mg/l.

Recent studies by the National Marine Fisheries Service indicate that significant mortalities of resident and anadromous fish have been caused by gas bubble disease resulting from exposure to nitrogen-supersaturated water. Studies are underway to determine the level of nitrogen in water than can be tolerated.

Biochemical oxygen demand (BOD) is a measure of the oxygen-demanding properties of the organic waste in the water. The BOD has little direct effect on the use of the water; but it does serve as an indicator of the general level of water quality. The BOD does not necessarily deplete the dissolved oxygen in a river if the rate of natural reaeration is high and the water temperatures are too cold for microbiological activities; but, if a stream pools, such as in a reservoir, the reaeration rate decreases, the BOD is exerted, and the dissolved oxygen level diminishes. Water quality objectives for BOD have not been established because of the variable effects under different stream conditions. Background levels of BOD are generally about one mg/l.

Bacterial contamination is commonly measured by occurrence of coliform bacteria--organisms common to the intestinal tract of warm-blooded animals--which serve to indicate the level of presence of a possible source of disease. Coliform counts in the form of the most probable number per 100 ml (MPN/100 ml) or the millipore filter count per 100 ml (MF count/100 ml) are used as an indication of bacterial pollution from warm-blooded animals and, therefore, as an indication of the relative safety of contact with, or ingestion of, water. The water quality standards for all states in the region require that average coliform counts shall not exceed 1,000/100 ml. The acceptable median coliform count for a number of stream reaches that receive heavy recreation use or are of relatively undisturbed quality has been set at 240/100 ml.

Temperature is critical to the biota of a particular water and of great importance to water supply. Migration of anadromous fish requires a temperature range of 45 to 70° F (7° to 21° C); the state water quality standards require that no measurable increases from unnatural waste sources or activities shall be permitted which result in water temperatures exceeding 68° F (20° C). Rearing of both trout and salmon occurs in a somewhat narrower temperature range--50 to 65° (10 to 18° C); and spawning requirements are very narrow, with temperatures beyond the range of 45 to 55° F (7 to 13° C) destroying fish production if sustained beyond a very limited period of time. Increasing or decreasing temperature often serves as the trigger for spawning activities, metamorphosis, and migration. A fish might hatch too early in the spring to find an adequate amount of its natural food organisms because the food chain depends ultimately on plants whose abundance, in turn, is a function of day length and temperature. Some organisms require that their eggs be chilled before they will hatch properly. Cool water is also desirable for water supplies, both for aesthetic reasons and for efficiency in cooling applications.

Turbidity is an expression of the optical property of water which causes light to be scattered and absorbed rather than transmitted in straight lines. Excessive turbidity reduces light penetration into the water and, therefore, reduces photosynthetic activity of organisms, attached algae, and submersed vegetation. Turbidity is caused by the presence of sediments such as sand, silt, clay, finely divided organic matter, and other suspended matter such as bacteria and plankton.

Sediments are particularly damaging to gravel and rubble-type bottoms. The sediments fill the interstices between gravel and stones, thereby eliminating the spawning grounds for fish and the habitat of many aquatic insects and other invertebrate animals.

Many of the dissolved materials are essential for growth, reproduction, and the general well-being of aquatic organisms. Water devoid of dissolved materials is intolerable because pure water will not support aquatic life. The chlorides, carbonates, sulfates, and silicates of sodium, potassium, calcium, and magnesium are the most common. Traces of most other essential substances are also found. Generally, to maintain natural conditions, total dissolved materials should not be increased by more than one-third of the concentration that is characteristic of the natural condition of the water.

The chemical constituents termed "nutrients" stimulate aquatic growths. The exact nature of the nutrient balance which will produce algal blooms is not known; however, nitrogen and phosphorus appear to be the most significant factors in stimulating

excessive growths. The generally accepted threshold concentrations of soluble phosphate and inorganic nitrogen for stimulation of algal blooms are 0.01 mg/l as P and 0.30 mg/l as N, respectively.

Toxic materials cover a wide spectrum--from naturally occurring heavy metals, to radioactive materials, to complex pesticidal compounds. These materials should be viewed not in terms of tolerances but rather in terms of maintaining the most complete possible degree of their absence in waters.

Present Water Quality

An assessment of water quality is a statement of the purity and suitability for use of water at a series of points along a stream. The quality of water in a particular stream reach is determined by the cumulative effects on, and characteristic changes in, water resulting from impacts of its upstream environment.

Collection of useful water quality data has received great emphasis in the recent past. However, available quality information is less complete geographically than, for example, streamflow records. Locations at which continuous quality information has been collected for more than a decade are few in number and seldom complete enough for many uses. Types of data collected range the full gamut of quality parameters, although samples at individual stations may be analyzed for only a few parameters. Because of the interest and sampling activity of many agencies at all governmental levels, a large volume of data of varying types and degrees has been generated.

To facilitate quality data retrieval and to reduce the time-consuming effort of contracting many different agencies, the Federal Water Quality Administration (FWQA) 1/ is operating a national program for computerized storage and retrieval of water quality information, designated "STORET." At the present time in the Pacific Northwest, a large amount of quality data, collected principally by the FWQA, the states of Oregon and Washington, and other agencies is available through the STORET system. A similar system is available through the United States Geological Survey.

Surveillance efforts of the states of Oregon and Washington encompass monitoring of most of the interstate streams and numerous intrastate streams. Stream sampling in Idaho, Montana, Wyoming, Utah, and Nevada has been limited to short-term surveys in problem areas. However, with the adoption of water quality standards by the states in the Columbia-North Pacific Region, routine sampling stations are being established to determine compliance with the standards.

1/ On December 2, 1970, the FWQA was renamed The Environmental Protection Agency, Water Quality Office (EPA, WQO).

The Geological Survey maintains a quality sampling network for temperature, sediment, and inorganic chemical analyses. However, stations where inorganic chemical analyses are being made are not very numerous. In addition, the FWQA, in cooperation with the Geological Survey and the respective state, has established a water quality network. The samples are also analyzed for organic and biological populations.

The Columbia River has not experienced a serious dissolved oxygen depression. However, low dissolved oxygen concentrations occur in a number of major tributaries and smaller streams, normally as the result of heavy biochemical oxygen demand exerted by municipal, pulp and paper, and/or food-processing wastes. On the Snake River fish kills have resulted in Milner and American Falls Reservoirs from low oxygen content. In addition, the dissolved oxygen level is depressed several milligrams per liter below Brownlee Reservoir on the Snake River. The Boise River, a tributary of the Snake River, also experiences low dissolved oxygen levels during extreme low-flow conditions. The lower Willamette River in Portland Harbor has a long history of low dissolved oxygen during the months of July, August, and September.

Critical oxygen problems that inhibit the fishery exist seasonally at and below Long Lake in the Spokane River. A number of smaller streams also exhibit low seasonal dissolved oxygen levels, including the lower reaches of the Duwamish, Chehalis, South Santiam, and Tualatin Rivers.

The stream reaches with low dissolved oxygen (previously discussed) have high biochemical oxygen demands, as would be expected. In addition, many water bodies in the Puget Sound and Coastal Subregions have high BOD levels, primarily as a result of municipal or pulp and paper mill wastes. However, the short time-of-travel before these waters enter the ocean or strong currents in the Sound prevents the exertion of the complete biochemical oxygen demand on the river.

Bacterial pollution resulting from municipal wastes and, in some cases, from animal populations has seriously damaged use for water-contact sports in a number of locations. The lower Willamette and the Columbia River below Portland generally have bacterial counts above the water quality standard of 1,000 organisms/100 ml, which applies to these stream reaches. Similar conditions are prevalent below larger population centers in the lower reaches of numerous streams, including Bear Creek; the Rogue, South Umpqua, Chehalis, Yakima, and Boise Rivers; and a number of Puget Sound streams. Some coastal waters such as Tillamook Bay and Port Angeles Harbor are similarly affected. The problem is quite important, especially since it generally occurs close to urban areas where the demand for water-based recreation is highest.

Maintaining an adequate temperature regimen is a significant problem complicating water resources management in the region. Water temperature levels are particularly important in the Columbia River and coastal streams since they are the fish passageways to spawning areas. At present, water temperature in the Columbia River below the Hanford Atomic Works exceeds water quality standards during the months of July, August, and September. The Columbia's major tributaries below Hanford (the Willamette, Yakima, and Snake Rivers) also have temperatures near or above the standards limit during much of this period. A number of coastal streams, including the Rogue, South Umpqua, and Chehalis Rivers, exhibit high water temperatures during the summertime low-flow period.

Nutrients such as nitrates and phosphates originating from both natural and manmade sources are the major cause of excessive aquatic growths in parts of the region such as the Yakima and Snake Basins and areas of the Columbia Basin Irrigation Project. In addition to taste and odor problems, these growths have increased maintenance costs to irrigators because of clogged diversion and distribution systems. Intensive algal growths cause extreme diurnal fluctuations in dissolved oxygen concentrations in some streams and reservoirs such as Brownlee. A recent fish kill in American Falls Reservoir has been attributed to low dissolved oxygen levels resulting from decomposition of dead algal cells. Other nutrients, derived principally from pulp and paper wastes, have contributed to the periodic slime problem in the lower Columbia River. Fouling of sport and commercial fishing gear has resulted from the slime growths.

Surface waters in the region generally contain less than 250 mg/l of dissolved solids, and only in a few small areas does the dissolved solids content exceed 1,000 mg/l. The streams in the mountainous parts of the region usually have a dissolved solids content of less than 100 mg/l, and some have less than 50 mg/l. The dissolved solids content of water in lakes with no outlets in the Oregon Closed Basin and Central Washington ranges from 1,000 to 70,000 mg/l or more.

Saltwater intrusion into the Columbia River estuary reaches about 23 miles upstream from the mouth. For the majority of streams adjacent to saline water, the extent and degree of saltwater intrusion are not accurately known.

Although irrigation is extensive, the majority of the streams in the region have a dissolved solids content of less than 500 mg/l. The chemical composition of the dissolved solids will vary, depending upon the soils of the drainage basin; but calcium, magnesium, and bicarbonate are usually the principal constituents. Sodium is a main constituent in some streams tributary to the Snake River.

The areas of greatest sediment yield are the windblown-soil areas in the Palouse and Walla Walla River basins of southeastern Washington. There is a considerable range in the quantity of fluvial sediment transported by the remaining streams in the region.

Streams draining the more arid parts of the region will, as a general rule, transport higher concentrations of fluvial sediment than those draining the humid, forested parts. However, on an annual basis, more sediment may often be transported from the forested areas because of more frequent storms and larger volumes of water. Streams originating from glaciers will transport rock material called "glacial flour" during the summer months when the glaciers are melting, while those whose low flow is derived from ground water will remain relatively free of fluvial sediment in summer. Short term sediment concentrations as high as 316,000 mg/l have been measured in the high-yield area near Walla Walla, Washington.

Many streams moving relatively small quantities of sediment may be turbid during the higher flow periods. Industries requiring water with very low concentrations of fluvial sediment or turbidity would have to treat, at some time during the year, almost all surface waters.

Toxic elements and compounds are not normally found in the waters of the region. However, some streams have been rendered biologically sterile and nonproductive because of mine wastes. This type of problem occurs in reaches of streams such as the South Fork Coeur d'Alene, Pend Oreille, and Clark Fork Rivers. In 1966, fish below American Falls Reservoir accumulated lethal dosages of pesticides in their livers and viscera. Other fish kills have been reported throughout the region from accidental spills of pesticides and other toxicants. Oil spills have been becoming an increasingly important pollution problem in the Puget Sound, Coastal and Willamette Subregions.

Supersaturated levels of dissolved nitrogen as high as 140 percent have recently been reported by the Bureau of Commercial Fisheries. The condition persists all along the Columbia River from Grand Coulee Dam to the mouth and in the Lower Snake River when flows are high enough to require spills. This condition presents a threat to migratory salmonids. If the fish are forced from the depths to the surface by barriers to their migration, or pass through significantly higher temperatures in thermal plumes, nitrogen bubbles can form in their bloodstreams, causing nitrogen embolism similar to "the bends." The supersaturation phenomenon, especially its persistence throughout the Lower Columbia, is not well understood as yet, and no specific limits have been set for dissolved nitrogen in state water quality standards. Any concentration of nitrogen in excess of saturation may result in a condition lethal to fish.

The potential of abnormally high, and perhaps even harmful, levels of radioactivity in the Columbia River, exists primarily as a consequence of discharges of the Hanford Atomic Works upstream from Richland, Washington. Levels of activity to date have not approached the limits established by the Atomic Energy Commission (AEC); and continuous monitoring by AEC and Battelle-Northwest, supplemented by that of the States of Washington and Oregon and FWQA, will provide adequate warning if a hazard develops. Radionuclides of particular concern in the Columbia River are zinc-65 and phosphorus-32. Zinc-65 and phosphorus-32 tend to concentrate in the food chain of organisms in the Columbia River. The Columbia River below Hanford Works has a mean count of 583 picocuries/liter. The Public Health Service (PHS) raw water supply standard is 1,000 picocuries/liter.

Summary of Problems

Figure 3 presents a graphical summary of major water pollution problem areas in the Columbia-North Pacific Region. The types of problems include bacterial contamination, low dissolved oxygen, high temperatures, prolific aquatic growths, and biological sterilization.

The most widespread and important problem from the public health aspect is that of bacterial contamination. Nearly every stream below major population centers fails to meet generally accepted coliform bacteria criteria for water-contact recreation and water supply sources.

Also particularly important in the region are the areas of low dissolved oxygen, since salmonid fish require dissolved oxygen levels of at least 5.0 mg/l for migration and higher levels for rearing and spawning. Most dissolved oxygen problems result from the discharge of inadequately treated municipal and industrial wastes. Impoundments also have a significant effect on the dissolved oxygen level.

High water temperatures (above 68° F, 20° C) in the lower Columbia and Lower Snake Rivers and several coastal streams have deleterious effects on anadromous fish.

Nitrogen supersaturation is a serious problem throughout the Lower Snake and Columbia Rivers. Nitrogen supersaturation results from spills over dams. High temperatures seem to magnify its toxic effect. A special study is underway to determine the reason for its persistence in the river, its lethal limits and possible solutions.

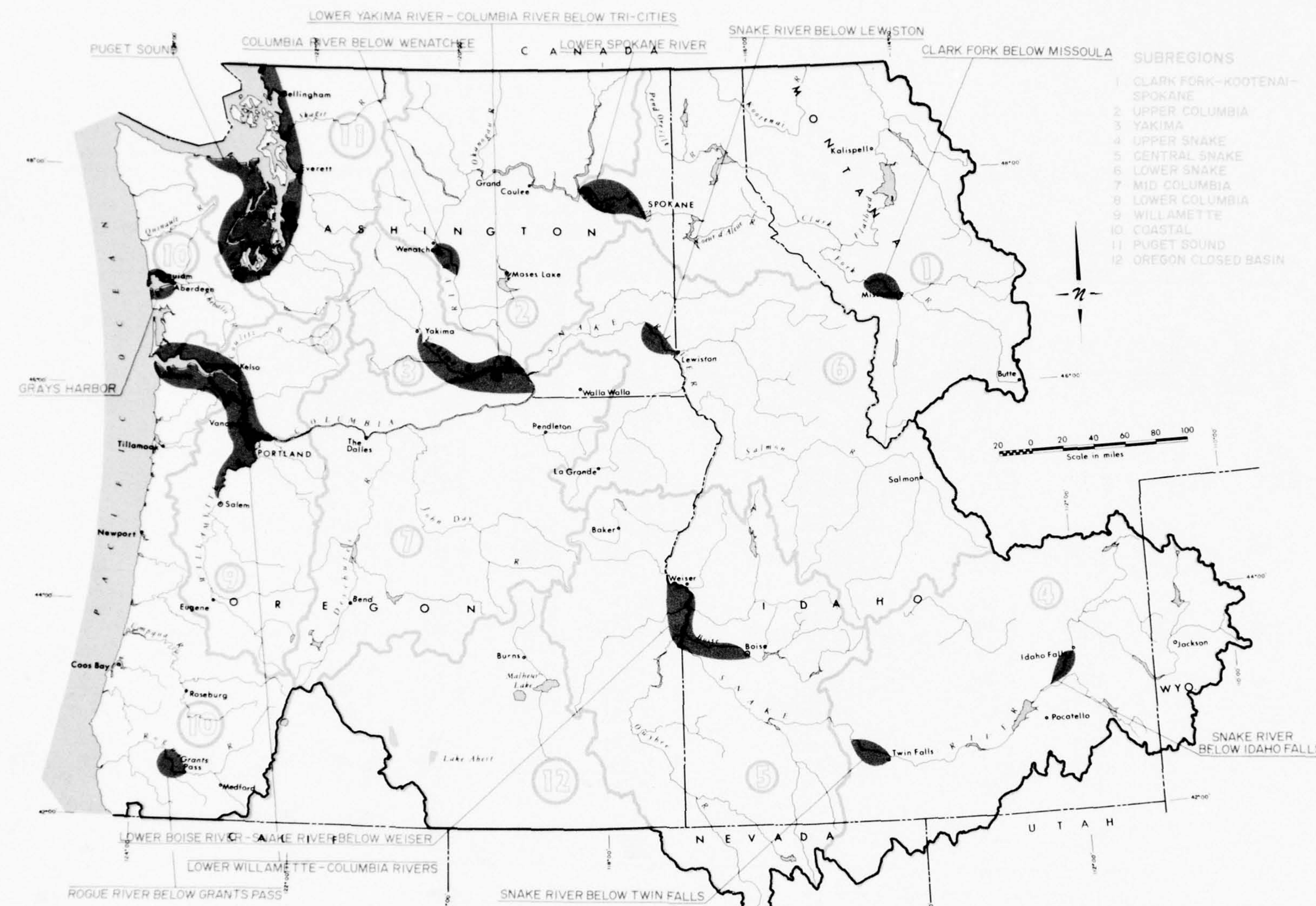
Aquatic growths which can cause taste and odor problems, clog irrigation canals, fish nets and lines, reduce aesthetic appearance, and depress dissolved oxygen levels, occur in a number of areas.

The Snake River and lower Columbia River are probably the most notable examples of this problem.

A few stream reaches have been rendered biologically sterile by the discharge of heavy metals from mining operations.

FUTURE WATER QUALITY MANAGEMENT NEEDS

The future demand for water quality control is related to the requirements both physical and institutional, which are necessary to assure that water quality is suitable for recognized beneficial water uses. This "demand" is somewhat different than that required to satisfy a given use such as municipal and industrial water supply or irrigation. The quality that must be maintained to allow future use has to be evaluated in terms of the use to be protected or enhanced. The demands for water quality control are, therefore, directly influenced by use-oriented water quality objectives. Such objectives have now been established for interstate and some intrastate waters of the Columbia-North Pacific Region by the Idaho Department of Health, Oregon Department of Environmental Quality, Montana Department of Health, and Washington Water Pollution Control Commission.



COLUMBIA-NORTH PACIFIC
COMPREHENSIVE FRAMEWORK STUDY
MAJOR WATER QUALITY
PROBLEM AREAS
C-NP REGION
1970

FIGURE 3

Table 3 - Present and Projected Population, Columbia-North Pacific Region[1/]

(thousands)

Subregion	1965	1980	2000	2020	Subregion	1965	1980	2000	2020
Clark Fork-Kootenai-Spokane	595.1	699.1	897.1	1140.5	Lower Columbia	220.3	254.9	324.4	414.3
Municipal	348.4	497.1	708.9	963.2	Municipal	82.8	156.6	245.4	358.4
Rural	246.7	202.0	188.2	177.3	Rural	137.5	98.3	79.0	55.9
Upper Columbia	250.2	322.5	430.8	548.0	Willamette[2/]	1,338.9	1,767.5	2,422.0	3,591.0
Municipal	134.9	193.4	290.1	395.9	Municipal	1,136.5	1,535.6	2,164.7	3,291.2
Rural	115.3	129.1	140.7	152.1	Rural	202.4	231.9	257.3	299.8
Yakima	184.5	211.2	258.4	327.0	Coastal	425.8	488.5	600.4	735.9
Municipal	98.1	132.5	189.6	265.0	Municipal	226.9	293.9	409.0	548.1
Rural	86.4	78.7	68.8	62.0	Rural	198.9	194.6	191.4	187.8
Upper Snake	302.0	350.9	450.5	576.5	Puget Sound	1,972.7	2,726.9	4,300.5	6,809.4
Municipal	136.1	212.3	336.0	488.8	Municipal	1,041.8	2,546.8	4,093.8	6,566.4
Rural	165.9	138.6	114.5	87.7	Rural	930.9	180.1	206.7	243.0
Central Snake	268.5	328.7	430.4	553.5	Oregon Closed Basin	13.3	16.3	18.7	21.3
Municipal	147.2	212.5	325.0	460.3	Municipal	4.5	6.9	9.5	12.5
Rural	121.3	116.2	105.4	93.2	Rural	8.8	9.4	9.2	8.8
Lower Snake	163.3	193.5	234.6	274.3					
Municipal	91.4	123.2	168.8	214.2					
Rural	71.9	70.3	65.8	60.1	Total C-NP Region	5,944.9	7,611.4	10,689.7	15,396.1
Mid Columbia	210.3	251.4	321.9	404.4	Municipal	3,560.8	6,063.2	9,159.4	13,855.2
Municipal	112.2	152.4	218.6	291.2	Rural	2,384.1	1,548.2	1,530.3	1,540.9
Rural	98.1	99.0	103.3	113.2					

1/ Derived from Economic Base and Projections, Appendix VI, C-NP Framework Study, January 1971, and from North Pacific Division Corps of Engineers data. Municipal populations in this table are assumed to be equal to the population served by a municipal sewage system. Differences in totals between the sources and this table are due to differences in subregion boundaries. The sources are based on economic boundaries and this table is based on hydrologic boundaries.

2/ Municipal population is that population within incorporated city limits. Note that all persons within a city are not necessarily served by municipal sewage treatment facilities. The rural population is the residual.

Future Waste Production

Future water quality will be affected by several economic factors--population growth, industrial expansion, irrigation, agricultural production, other land uses, and recreation. As this growth occurs, the production of wastes and water quality problems will likewise increase. Looking ahead to 1980 and beyond to 2000 and 2020 at these factors provides the primary source for: (1) projecting the quantity and location of wastes and (2) determining the means to preserve water quality and to protect the water uses of any given water-course.

Future water quality management needs are determined, in large part, by the magnitude of future municipal and industrial waste production. Projections of raw waste production have been made by utilizing information and economic factors developed in the Economic Base Study for Appendix VI, Columbia-North Pacific Region Comprehensive Framework Study.

The projected raw waste loads are generally expressed in population equivalents, which are used as a convenience to relate different waste sources to a common base. This equivalency applies only to the oxygen-demanding properties of a waste.

Table 4 - Present and Projected Municipal Raw Organic Waste Production - Columbia-North Pacific Region

Subregion	1970 1/	1980	2000	2020
		(1,000's P.E.)		
1	497.1	620.7	886.2	1204.2
2	193.0	241.8	362.6	494.9
3	137.0	165.6	237.0	331.3
4	201.9	265.3	420.0	611.0
5	211.3	265.7	406.2	575.4
6	127.1	154.0	211.0	267.8
7	157.6	191.2	272.2	364.0
8	134.2	195.7	306.8	448.0
9	1,559.9	1,915.8	2,699.7	4,103.9
10	312.3	367.3	511.2	685.0
11	1,929.4	3,183.6	5,118.0	8,208.0
12	6.6	8.6	11.9	15.6
TOTALS	5,467.4	7,575.3	11,442.8	17,309.1

1/ Interpolated between 1965 data and 1980 projections to determine population.

Municipal

The municipal waste production estimates are based on distributed populations shown in table 3. A factor of 1.25 was applied to the municipal population components to account for the effects of small commercial establishments and other urban activities which add to municipal waste loads. The projected municipal raw wastes for the region and subregions are presented in table 4.

Municipal raw wastes are projected to increase from 5.5 million PE in 1968 to 17.9 million PE in the year 2020. Seventy percent of these wastes will be generated in the Willamette and Puget Sound Subregions.

Industrial

Industrial waste production was estimated for pulp and paper, lumber and wood products, food products, primary metals and chemical products by subregion. For these industries, future waste production is the product of present raw waste production and a growth index; however, consideration has been given anticipated changes in in-plant technology which will result in a lower waste production than

Table 5 - Industrial Growth Indices
Columbia-North Pacific Region (5)

Subregion	Food Products 1/ (5)			Pulp and Paper 2/ (5)			Lumber and Wood Products 2/ (21)			Primary Metals 3/ (17)			Chemicals 3/ (17)		
	1980	2000	2020	1980	2000	2020	1980	2000	2020	1980	2000	2020	1980	2000	2020
1	1.29	1.79	2.46	1.95	3.29	3.59	0.99	0.91	0.87	1.29	1.44	1.74	1.37	1.93	2.66
2	2.17	3.44	5.22	2.67	4.33	6.67	1.36	1.55	1.63	1.37	1.67	1.97	1.27	1.59	1.91
3	1.62	2.36	3.39	-	-	-	1.39	1.69	1.85	-	-	-	1.24	1.35	1.85
4	1.70	2.46	3.13	-	1.00	2.92	1.14	1.14	1.00	-	-	-	1.50	2.20	3.02
5	1.63	2.36	3.05	1.00	2.62	5.35	1.12	1.22	1.13	-	-	-	-	-	-
6	1.84	2.54	2.79	1.21	1.38	1.56	1.17	1.28	1.21	-	-	-	-	-	-
7	1.66	2.30	3.18	1.34	2.12	2.31	1.09	1.16	1.23	2.93	3.29	3.67	-	-	-
8	1.54	2.15	2.97	1.48	2.13	2.34	0.92	0.96	0.88	1.94	2.21	2.47	1.53	2.31	3.23
9	1.48	2.05	2.86	2.14	2.71	2.81	0.69	0.69	0.72	1.93	2.17	2.42	1.53	2.31	3.23
10	1.63	2.25	3.12	1.90	2.49	2.64	0.82	0.77	0.73	2.73	4.08	5.06	1.53	2.31	3.23
11	1.50	2.09	2.88	1.42	2.07	2.27	1.16	1.13	0.95	1.27	1.31	1.34	1.42	1.98	2.62
12	1.61	3.21	4.40	-	-	-	1.04	1.04	1.07	-	-	-	-	-	-
Total Region	1.57	2.22	3.02	1.62	2.33	2.59	0.93	0.92	0.89	1.55	1.76	1.97	1.37	1.85	2.41

1/ Base year - 1963. 2/ Base year - 1965. 3/ Base year - 1960.

calculated using the growth index. Raw waste projections for Subregions 9 and 11 were determined from the respective type 2 studies rather than the indices shown for those subregions. As in the other subregions, the projected waste production was reduced due to anticipated technology changes.

The growth indices are shown in table 5. No attempt has been made to reduce the indices to a single base year as it is felt that the reliability of projections made using any current inventory would be unaffected. The base years have been indicated so that value judgments could be made by the user, if necessary.

Total industrial raw waste production estimates for 1980, 2000, and 2020 are presented in table 6 for each subregion.

Table 6 - Present and Projected Industrial Raw Organic Waste Production - Columbia-North Pacific Region 1/

Subregion	1970 2/	1980	2000	2020
		(1,000's P.E.)		
1	590.7	792.2	974.8	1,104.5
2	2,252.9	3,206.1	5,097.0	7,717.3
3	553.2	1,201.5	1,731.9	2,502.1
4	3,229.9	4,547.0	6,710.0	8,519.0
5	947.7	1,418.0	2,355.0	3,521.0
6	534.3	626.2	738.3	831.2
7	1,508.7	2,030.7	2,672.3	3,472.3
8	3,776.2	4,709.5	6,861.0	7,547.5
9 3/	3,450.2	4,141.9	5,954.7	7,652.1
10	5,433.6	7,799.0	9.391.0	10,290.0
11 3/	14,334.0	15,008.0	16,454.0	18,886.0
12	--	--	--	--
Total C-NP Region	36,611.4	45,480.1	58,940.0	72,043.0

1/ Base data from FWPCA inventory of municipal and industrial wastes, 1968.
2/ Interpolated from 1965 data and 1980 projections.
3/ Considers changes in in-plant processes.

The industrial waste load is expected to increase from about 33.4 million PE in 1965 to nearly 91 million PE in the year 2020. The pulp and paper industry will remain the largest waste source, accounting for over 71 percent of the organic loading in 2020. It was assumed for projection purposes that all new pulp mills in the region would be of the sulfate (kraft) process. The food products industry will continue to be the next largest industrial waste source, producing about 25 million PE by the year 2020. The lumber and wood products and other miscellaneous industries are expected to be relatively minor industrial organic waste sources.

The primary metals and chemical products industries will be important sources of inorganics, heat, and sometimes toxic waste material. The future magnitude and nature of these wastes are difficult to determine and will be discussed in applicable sub-regional sections.

Waste heat produced by thermal power plants will be a potential threat to water quality--and in particular to the ecological balance of region waters. Because once-through cooling will not be practiced on inland streams in the immediate future, major water quality problems are not anticipated.

Table 7 - Present and Projected Rural-Domestic Raw Organic Waste Production - Columbia-North Pacific Region

Subregion	1970 1/	1980	2000	2020
		(1,000's P.E.)		
1	231.9	202.0	188.2	177.3
2	119.9	129.1	140.7	152.1
3	83.8	78.7	68.8	62.0
4	157.1	138.6	114.5	87.7
5	119.5	116.2	105.4	93.2
6	71.4	70.3	65.8	60.1
7	97.8	99.0	103.3	113.2
8	124.4	98.3	79.0	55.9
9	602.2	231.9	257.3	299.8
10	197.1	194.6	191.4	187.8
11	680.9	181.0	206.7	243.0
12	9.0	9.4	9.2	8.8
Total C-NP Region	2,495.0	1,549.1	1,530.3	1,540.9

1/ Interpolated from 1965 data and 1980 projections.

Rural-Domestic

The rural-domestic waste production was projected as equal to the rural population component as shown in table 3. The projected rural waste production by subregion is summarized in table 7 for the years 1970, 1980, 2000, and 2020.

Irrigation

At present, irrigation is the greatest water consumer and depletes the water resource the most. In 1965, there were approximately 7.34 million acres of irrigated land, which required an annual water diversion rate of 4 1/2 acre-feet per acre. About 45-50 percent of the diverted water is actually consumed, and the remainder returns to the streams directly through channels or indirectly through ground-water aquifers. It is estimated that by the year 2020 about 13.5 million acres of land will be irrigated; however, the diversion rate is expected to decrease. Depletion of water for irrigation use will increase to almost 30 million acre-feet.

A summary of projected irrigated acreage by subregion is presented in table 8. The major areas of irrigation will continue to be in the Upper and Central Snake, Upper Columbia, and Yakima Subregions. The Mid Columbia and Willamette Subregions will probably experience significant irrigation developments. As more and more area is irrigated, the potential for water depletion and the resultant water quality problems increase.

Table 8 - Projected Total Irrigated Area
Columbia-North Pacific Region (8)1/

Subregion	1980	2000	2020
		Thousand Acres, rounded	
1	860	950	1,320
2	1,280	1,490	1,920
3	550	570	610
4	2,920	3,030	3,210
5	1,950	2,120	2,460
6	440	550	770
7	860	950	1,220
8	60	70	100
9	430	850	1,000
10	280	290	330
11	138	186	223
12	330	340	340
Regional Total	10,098	11,396	13,503

1/ These data are approximately 3 percent greater than total irrigated cropland as shown in table 9, reflecting an allowance for irrigated noncropland.

Table 9 - Land, Uses, 1966 and Projections for 1980, 2000, and 2020
Columbia-North Pacific Region and Subregions (5)

Subregion	Land Use	1966	1980	2000	2020
			(Thousands of Acres)		
1	Cropland	1,552	1,737	1,739	1,930
	Irrigated	(465)	(833)	(925)	(1,280)
	Nonirrigated	(1,087)	(904)	(814)	(650)
	Forest	18,242	18,118	17,974	17,784
	Range	1,698	1,439	1,411	1,237
	Other	1,327	1,414	1,530	1,644
	Miscellaneous	(212)	(225)	(245)	(272)
	Total	22,819	22,708	22,654	22,595
2	Cropland	3,309	3,451	3,345	3,300
	Irrigated	(707)	(1,242)	(1,448)	(1,866)
	Nonirrigated	(2,602)	(2,209)	(1,897)	(1,434)
	Forest	5,652	5,624	5,653	5,674
	Range	4,584	4,363	4,360	4,300
	Other	536	570	616	662
	Miscellaneous	(108)	(114)	(122)	(131)
	Total	14,081	14,008	13,974	13,936
3	Cropland	686	724	736	768
	Irrigated	(490)	(536)	(552)	(590)
	Nonirrigated	(196)	(188)	(184)	(178)
	Forest	1,509	1,500	1,490	1,468
	Range	1,535	1,486	1,462	1,428
	Other	121	135	153	173
	Miscellaneous	(52)	(57)	(65)	(73)
	Total	3,851	3,845	3,841	3,837
4	Cropland	3,781	3,906	3,872	3,860
	Irrigated	(2,410)	(2,842)	(2,944)	(3,119)
	Nonirrigated	(1,371)	(1,064)	(928)	(741)
	Forest	4,297	4,273	4,254	4,206
	Range	13,556	13,362	13,355	13,350
	Other	1,048	1,069	1,097	1,127
	Miscellaneous	(107)	(114)	(124)	(136)
	Total	22,682	22,610	22,578	22,543
5	Cropland	1,629	2,082	2,184	2,453
	Irrigated	(1,421)	(1,900)	(2,062)	(2,389)
	Nonirrigated	(208)	(182)	(122)	(64)
	Forest	4,191	4,174	4,152	4,129
	Range	16,839	16,332	16,200	15,897
	Other	739	764	795	830
	Miscellaneous	(73)	(80)	(90)	(102)
	Total	23,398	23,352	23,331	23,309
6	Cropland	3,078	3,058	3,046	3,035
	Irrigated	(268)	(432)	(531)	(743)
	Nonirrigated	(2,810)	(2,626)	(2,515)	(2,292)
	Forest	13,537	13,492	13,436	13,380
	Range	5,042	5,040	5,038	5,036
	Other	714	763	823	882
	Miscellaneous	(49)	(53)	(57)	(60)
	Total	22,371	22,353	22,343	22,333
7	Cropland	3,571	3,729	3,735	3,805
	Irrigated	(525)	(834)	(918)	(1,186)
	Nonirrigated	(3,046)	(2,895)	(2,817)	(2,619)
	Forest	8,328	8,274	8,206	8,118
	Range	6,358	6,176	6,162	6,106
	Other	565	613	675	733
	Miscellaneous	(81)	(86)	(93)	(101)
	Total	18,822	18,792	18,778	18,762

Table 9 (Cont.)

Subregion	Land Use	1966	1980	2000	2020
			(Thousands of Acres)		
8	Cropland	201	176	145	134
	Irrigated	(17)	(54)	(66)	(98)
	Nonirrigated	(184)	(122)	(79)	(36)
	Forest	2,665	2,652	2,649	2,618
	Range	68	65	60	60
	Other	259	282	312	344
	Miscellaneous	(51)	(52)	(54)	(58)
	Total	3,193	3,175	3,166	3,156
9	Cropland	1,456	1,384	1,420	1,250
	Irrigated	(244)	(417)	(824)	(970)
	Nonirrigated	(1,212)	(967)	(596)	(280)
	Forest	5,272	5,221	5,056	5,089
	Range	59	55	50	48
	Other	816	911	1,031	1,156
	Miscellaneous	(555)	(613)	(683)	(770)
	Total	7,603	7,571	7,557	7,543
10	Cropland	585	472	421	370
	Irrigated	(175)	(270)	(284)	(316)
	Nonirrigated	(410)	(202)	(137)	(54)
	Forest	13,829	13,795	13,747	13,700
	Range	168	160	150	140
	Other	472	587	676	764
	Miscellaneous	(124)	(133)	(143)	(156)
	Total	15,054	15,014	14,994	14,974
11	Cropland	591	470	403	385
	Irrigated	(92)	(134)	(180)	(216)
	Nonirrigated	(499)	(336)	(223)	(169)
	Forest	6,429	6,419	6,336	6,189
	Range	105	105	100	92
	Other	1,322	1,433	1,576	1,737
	Miscellaneous	(567)	(634)	(721)	(828)
	Total	8,447	8,427	8,415	8,403
12	Cropland	365	363	361	352
	Irrigated	(317)	(324)	(326)	(332)
	Nonirrigated	(48)	(39)	(35)	(20)
	Forest	1,893	1,874	1,842	1,805
	Range	8,733	8,726	8,741	8,767
	Other	404	413	424	436
	Miscellaneous	(8)	(8)	(9)	(9)
	Total	11,395	11,376	11,368	11,360
C-NP	Cropland	20,804	21,552	21,407	21,642
	Irrigated	(7,132)	(9,819)	(11,060)	(13,105)
	Nonirrigated	(13,672)	(11,733)	(10,347)	(8,537)
	Forest	85,844	85,416	84,795	84,160
	Range	58,745	57,309	57,089	56,461
	Other	8,323	8,954	9,708	10,488
	Miscellaneous	(1,987)	(2,169)	(2,406)	(2,696)
	Total	173,716	173,231	172,999	172,751

Other Land Uses

Forest, range, crop, and urban lands will receive more intensive utilization during the projection period. As a result, land use and management practices will become increasingly significant waste sources. The increased use of fertilizers, pesticides, and herbicides will also have important water quality impacts.

Projections of land use in the Columbia-North Pacific Region, by major types of land use, are shown in table 9. The four types of land use projected are cropland, forest and woodland, range and pasture land, and other land for the years 1966, 1980, 2000, and 2020. The other land use category is composed of barren land, roads and railroads, small bodies of water, industrial areas, farmsteads, and airports.

The projections show a decrease in forested land area of approximately three percent by the year 2020. In contrast, the wood consumption demand by the pulp and paper, and lumber and wood products industries is expected to increase by 1-1/4 times during the same period. The potential for erosion and stream damage will be greater as more intensive harvesting methods are employed by forest users.

Aside from sediment the most important waste source from croplands during the projection period will be fertilizers, pesticides, and herbicides. Once these materials have entered the receiving waters, they cannot be "managed" in the usual sense of the word. Present monitoring techniques are not capable of detecting the small concentrations that can cause damage to aquatic organisms. If too high a concentration of these compounds reaches the water courses, by direct application, rainfall runoff, or irrigation return flows, a significant deterioration of water quality will occur. It is expected that the use of fertilizers will be more widespread, since an average increase in crop yield is projected and only a slight increase in land area for crops is anticipated.

Livestock and big game animals feeding on range and pasture lands near watercourses are potential pollution hazards. If animal populations grow too large, overgrazing and accelerated erosion will result. However, this problem is not expected to increase significantly in the future, since the trend will be to concentrate large numbers of animals in feedlots.

Runoff from urban areas will have an impact on water quality in several parts of the region that will exceed that of agricultural drainage. Besides the flushing of materials to watercourses that accompanies precipitation, urban area runoff that is channeled through sanitary sewers may cause an overloading of sewage treatment plants that forces the discharge of inadequately treated wastes to streams.

Agricultural Animals

Farm animals, whether fed in concentrated lots or grazed on pastures, will produce large amounts of waste. A summary of organic waste production by the livestock population in the region is presented in table 10 for 1980, 2000, and 2020. As shown in the table, it is estimated that a waste production equivalent to 84.3 million PE will be generated daily by the year 2020. It is expected that more cattle will be on feedlots by the year 2020, and runoff from feedlots and stockyards will pose a health problem, as well as a possible depletion of oxygen in receiving waters. A study now being established on the dairy herd located on Washington State's honor farm near Monroe, Washington, should provide considerable specific information on the dairy cattle waste problem.

Table 10 - Projected Livestock Raw Organic Waste Production
Columbia-North Pacific Region (5) (16) (20)

Subregion	1980	2000	2020
	Million Population Equivalents 1/,2/		
1	4.2	5.5	7.3
2	4.4	5.9	7.7
3	3.4	4.5	5.9
4	8.8	12.0	15.8
5	7.9	10.5	13.8
6	4.2	5.6	7.4
7	5.7	7.6	10.0
8	1.5	2.3	3.1
9	3.0	4.0	5.2
10	1.4	1.8	2.4
11	3.8	5.0	6.6
12	1.3	1.8	2.3
Total C-NP Region	49.6	66.5	87.5

1/ Based on BOD.
2/ Growth indices used to develop population equivalents are based on economic boundaries. No significant difference results from use of economic boundaries or hydrologic boundaries for agricultural projections.

Recreation

Recreation is expanding in ever-increasing forms. Wastes generated by recreational activities are expected to increase to 6 million PE by 2020--approximately 5 times present levels. People gathered at campgrounds, at beaches, on lakes, and on small streams

or rivers are expected to be significant sources of bacterial contamination and litter in the form of trash and garbage. Organic oxygen demand is only a secondary factor for recreational wastes.

Recreational waste production was based primarily on projections of water-related and non-water-related recreation days. Projected raw wastes summarized for the region are shown on table 11.

Table 11 - Projected Recreational Raw Waste Production
Columbia-North Pacific Region 1/

Subregion	1970	1980	2000	2020
		(1,000's P.E.)		
1	119.5	162.0	298.0	549.0
2	76.0	103.0	189.0	345.5
3	42.0	57.5	105.5	195.0
4	90.0	122.5	225.0	414.5
5	95.0	128.5	237.0	436.5
6	43.5	59.0	108.5	200.5
7	76.0	115.5	213.0	392.0
8	31.0	43.0	77.5	143.0
9	169.4	229.0	428.2	801.2
10	253.0	344.0	633.0	1,166.0
11	262.6	360.8	696.8	1,351.8
12	8.6	11.0	19.0	34.5
Total C-NP Region	1,266.6	1,735.8	3,230.5	6,029.5

1/ Bureau of Outdoor Recreation and U. S. D. A. Forest Service Projections for total man recreation days (TMRD).

Navigation and Dredging

Navigation and dredging activities are expected to increase in magnitude and scope during the projection period. The steadily increasing trend toward large freshwater barges and large carriers in the ocean trade may necessitate further deepening and widening of existing or authorized channels. Disposal of spoils from construction and maintenance of channels is expected to become more of a problem as available land area decreases and land becomes more valuable.

The primary potential source of oil pollution will be the discharge from vessels of oil-contaminated ballast and bilge. The problems resulting from accidental spills of oil and other hazardous

materials, whether from carriers of from land-based facilities, can be extremely serious. The potential size of spills is proportional to the columes of material handled, and the size of carriers, pipelines, and storage facilities is constantly increased.

QUALITY GOALS

The Water Quality Standards that have been adopted by each state in the region are the quality goals for that state. These Water Quality Standards were adopted to protect the water quality suitable for the beneficial uses. There is a wide variety of uses which provide immeasurable benefits, both economic and social. These benefits include water supply for industrial, agricultural, and municipal use, a natural habitat for fish and wildlife, water-oriented recreation, and transportation. The benefits related to social values and mental and physical welfare such as aesthetics are impossible to quantify in economic terms. Whether quantifiable or not, they are very real, and their loss would have a significant social and economic impact.

Past experience shows that, as our knowledge increases, water quality requirements become more restrictive. Increasing understanding of the relationship between man's activities and water quality has seldom, if ever, resulted in a relaxation or lessening of water quality requirements. This trend will undoubtedly continue.

Some waters have a higher quality than the minimum levels assigned for protection of water uses. The states have recognized that scientific knowledge to determine the exact water quality requirements to protect specific uses is limited, and have subscribed to the "anti-degradation" provision. Following is a general statement of the provision:

> "Waters whose existing quality is better than the established standards as of the date on which such standards become effective will be maintained at that high quality unless it has been affirmatively demonstrated to the state that a change is justifiable as a result of necessary economic or social development and will not preclude present and anticipated use of such waters. Any industrial, public or private project or development which would constitute a new source of pollution or an increased source of pollution to high quality waters will be required to provide the necessary degree of waste treatment to maintain high water quality. In implementing this policy, the Secretary of the Interior will be kept advised in order to discharge his responsibilities under the Federal Water Pollution Control Act, as amended."

Washington

Washington has elected to use the classification method for the major water streams in the state. The streams are classified according to use, and criteria are established to protect the quality to secure those uses. Table 12 is a non-inclusive list of uses to be protected by the various classifications.

The following parameters are commonly used for the water quality criteria: (1) Dissolved Oxygen, expressed in either milligrams per liter (mg/l) or percent saturation; (2) Total Coliform Organisms, as measured in terms of the "most probable number" (MPN) or the equivalent "membrane filter" (MF) technique, expressed in organisms per 100 milliliters; (3) pH, the negative logarithm of the hydrogen ion concentration; and (4) Temperature, F.

Table 12 - Characteristic Uses to be Protected, Washington
Columbia-North Pacific Region

Uses	Watercourses Classification AA	A	B	C
Fisheries				
Salmonid				
Migration	F M	F M	F M	F M
Rearing	F M	F M	F M	
Spawning	F	F		
Warm Water Game Fish				
Rearing	F	F	F	
Spawning	F	F	F	
Other Food Fish	F M	F M	F M	
Commercial Fishing	F M	F M	F M	
Shellfish	M	M	M	
Wildlife	F M	F M	F M	
Recreation				
Water Contact	F M	F M	F M	
Boating and Fishing	F M	F M	F M	F M
Environmental Aesthetics	F M	F M	F M	F M
Water Supply				
Domestic	F	F		
Industrial	F M	F M	F M	F M
Agricultural	F	F	F	F
Navigation	F M	F M	F M	F M
Log Storage & Rafting	F M	F M	F M	F M
Hydro-power	F	F	F	F

F - Fresh Water M - Marine Water

Table 13 shows the general water quality criteria for the various classifications. Special conditions for total coliform organisms and temperature have been established for a number of specified water bodies. However, in no case is the median coliform density to exceed 1,000/100 ml when associated with any fecal source. For a number of Class A fresh waters supporting salmonid fisheries, the water temperature standard has been set at 68°F. Other, less specific, criteria are "toxic or deleterious substances" and "aesthetic values" and are expressed in narrative rather than in numerical values. Toxic, Radioactive, or Deleterious Material Concentrations shall be below those which affect public health or which may cause acute or chronic toxic conditions in the aquatic biota, or which may adversely affect any water use. Aesthetic Values shall not be impaired by the presence of materials or their effects, excluding those of natural origin, which offend the senses of sight, smell, touch, or taste, and affect water usage or taint the flesh of edible species.

Table 13 - Generalized Water Quality Standards Criteria for Washington

	Class			
Water Quality Criteria	AA	A	B	C
Total Coliform Organisms/100 ml (median values)				
Fresh Water	50	240	1,000	1,000
Marine Water	70	70	1,000	1,000
Dissolved Oxygen mg/l (Minimum permissible limits)			70% Sat.	50% Sat.
Fresh Water	9.5	8.0	6.5	5.0
Marine Water	7.0	6.0	5.0	4.0
Temperature 1/				
Fresh Water	60° F	65° F	70° F	75° F
Marine Water	55° F	61° F	66° F	72° F
Turbidity	< 5 JTU	< 5 JTU over natural conditions	< 10 JTU over natural conditions	< 10 JTU over natural conditions

1/ Special conditions regarding temperature for specific stream reaches.

Minor streams not classified are covered with a general statement.

Washington is in the process of adopting intrastate Water Quality Standards, which include a separate classification for lakes. The uses for lakes are the same as for Class AA waters except for navigation and shellfish reproduction. The criteria call for coliform organisms not to exceed a median value of 240 organisms per 100 ml, and 20 percent of the samples should be less than 1,000 per 100 ml when associated with any fecal source. Dissolved Oxygen, Temperature, and pH should have no change over natural conditions. Turbidity should not exceed 5 JTU over natural conditions.

Oregon

General Water Quality Standards have been adopted for Oregon which apply to all waters of the state except where they are superseded by Special Water Quality Standards applicable to specifically designated waters of the state. The General Standards protect " . . . existing and contemplated needs and uses of water for domestic, municipal, irrigation, power development, industrial, mining, recreation, wildlife and fish life uses, and for pollution abatement, all of which are declared to be beneficial uses, and all other related subjects, including drainage and reclamation." The Special Water Quality Standards are adopted for the purpose of protecting, together with pertinent General Water Quality Standards, the beneficial uses of specified waters of the state as set forth in table 14.

In accordance with the following General Water Quality Standards, no wastes shall be discharged and no activities shall be conducted which either alone or in combination with other wastes or activities will cause in any waters of the state:

1. The dissolved oxygen content of surface waters to be less than six (6) milligrams per liter unless specified otherwise by special standard.

2. The hydrogen-ion concentration (pH) of the waters to be outside the range of 6.5 to 8.5 unless specified otherwise by special standard.

3. Any measurable increase in temperature when the receiving water temperatures are 64° F or above, or more than 2° F increase when receiving water temperatures are 62° F or less.

4. Radioisotope concentrations to exceed Maximum Permissible Concentrations (MPC's) in drinking water, edible fishes or shellfishes, wildlife, irrigated crops, livestock and dairy products or pose an external radiation hazard.

The General Standards further set forth that no wastes shall be discharged and no activities shall be conducted which either alone or in combination with other wastes or activities will cause in any waters of the state:

1. The liberation of objectionable concentrations of dissolved gases.

2. The stimulation of fungi and other undesirable growths.

3. The creation of objectionable tastes or odors or toxic and other conditions.

4. The formation of deleterious organic or inorganic sludge deposits.

5. Objectionable discoloration, turbidity, scum, oily slick, or floating solids or coat the aquatic life with oil films.

6. Bacterial pollution.

7. Aesthetic conditions offensive to human senses of sight, taste, smell, or touch.

The Special Water Quality Standards criteria applicable to waters shown in table 14 are discussed in the respective subregional sections.

Table 14 - Beneficial Uses to be Protected, State of Oregon

	Domestic Water Supply 1/	Industrial Water Supply 1/	Irrigation	Livestock Watering	Anadromous Fish Passage	Salmonid Fish Rearing	Salmonid Fish Spawning	Resident Fish and Other Aquatic Life	Hunting and Wildlife	Fishing	Water Skiing & Swimming	Pleasure Boating	Aesthetic Qualities	Navigation
Grande Ronde River	X	X	X	X	X	X	X	X	X	X	X	X	X	
Walla Walla River	X	X	X	X	X	X	X	X	X	X	X	X	X	
Snake River	X	X	X	X	X2/	X	X	X	X	X	X	X	X	
Columbia River	X	X	X	X	X	X	X	X	X	X	X	X	X	
Willamette River														
(Mouth to Willamette Falls incl. Mult. Channel)	X3/	X	X	X	X	X		X	X	X	X4/	X	X	X
(Willamette Falls to Newberg)	X	X	X	X	X	X		X	X	X	X	X	X	X
(Newberg to Salem)	X	X	X	X	X	X	X	X	X	X	X	X	X	X
(Salem to Coast Fork)	X	X	X	X	X	X	X	X	X	X	X	X	X	
Marine and Estuarine		X			X	X		X	X	X	X	X	X	X

1/ With adequate pre-treatment
2/ Up to Oxbow Dam (River mile 273)
3/ If no better source is reasonably attainable
4/ Not to confict with commercial activities in Portland Harbor

Idaho

Water Quality Standards have been established for Idaho to preserve and enhance the quality of the waters of the state for multiple, legitimate, beneficial uses, including domestic purposes, irrigation, industrial uses, fish and wildlife propagation, recreation, and aesthetic purposes.

The following General Water Quality Standards apply to all waters of the state in addition to the Water Quality Standards set forth for specifically identified waters. Waters of the state shall not contain:

1. Toxic chemicals of other than natural origin in concentrations found to be of public health significance or to adversely affect the use indicated. (Guides such as the Water Quality Criteria, published by the State of California Water Quality Control Board (Second Edition, 1963), will be used in evaluating the tolerances of the various toxic chemicals for the use indicated.)

2. Deleterious substances of other than natural origin in concentrations that cause tainting of edible species or tastes and odors to be imparted to drinking water supplies.

3. Radioactive materials or radioactivity in water which (1) exceeds 1/30th of the MPC values given in Column 2, Table I, Appendix A, Part C, Rules and Regulations for the Control of Radiation in the State of Idaho, (2) exceeds concentration limits of the Idaho Drinking Water Standards for waters used for, or likely to be used for, domestic supplies, (3) results in accumulations of radio-activity in edible plants and animals that present a hazard to consumers, and/or (4) is harmful to aquatic life.

4. Floating or submerged matter not attributable to natural causes.

5. Excess nutrients of other than natural origin that cause visible slime growths or other nuisance aquatic growths.

6. Visible concentrations of oil, sludge deposits, scum, foam, or other wastes that may adversely affect the use indicated.

7. Objectionable turbidity which can be traced to a point source or sources.

Numerical standards have been developed for waters of the state as shown in table 15. The stream standards are applicable except when differences occur between numerical values and those adopted for specifically identified interstate waters. These differences will be discussed in respective subregion sections. The standards for headwater areas are for waters that are presently upstream from existing significant waste sources, while the identical criteria for lakes and reservoirs refer to those used primarily for recreation, drinking water supplies, fish and wildlife propagation, and/or aesthetic purposes.

Table 15 - Generalized Water Quality Standards Criteria for Idaho

Water Quality Criteria	Streams	Headwater Areas, Lakes & Reservoirs
Dissolved Oxygen	>75% saturation and 100% during spawning season	>75% saturation and 100% during spawning season
Total Coliform Organisms	<1,000/100 ml	<240/100 ml
pH	6.5 to 9.0 (Induced variation <0.5)	6.5 to 9.0 (Induced variation <0.5)
Temperature	68°F. with <2° increase	<66°F. with <2° increase
Turbidity	<10 JTU over natural conditions	<5 JTU over natural conditions
Phosphorus and Nitrogen Compounds	--	No measurable concentration over natural conditions

Montana

The State of Montana designates the following uses to be protected in all state waters:

Public water supply
Industrial water supply
Fishing and recreation
Agriculture
Water power
Industrial waste use

Montana utilizes a stream classification system for designating water uses and for establishing criteria to serve these uses. All waters must be aesthetically pleasing, and this quality is usually protected by narrative criteria preventing unsightly or obnoxious conditions, such as floating debris, oil slicks, unpleasant odors, and colors. Specific use designations for all waters covered by the standards are shown in table 16. The exact use designation for a particular stream reach can be obtained from the Montana State Department of Health.

Wyoming

Wyoming Water Quality Standards provide protection of waters for all uses under present conditions. Ten basic standards and several variable standards have been adopted for the portion of Wyoming in the Columbia-North Pacific Region. The basic standards evolve from the fact that some parameters are common to all uses, and one use (fisheries) is common to all waters under consideration. Basic water quality standards call for waters to be essentially free from settleable solids; floating solids; taste, odor, and color problems; and toxic substances. In addition, the standards state that public water supplies will meet Public Health Service Drinking Water Standards and that radioactive materials shall not exceed limits established in 1962 PHS Drinking Water Standards or 1/30 (168-hour value) of the values for radioactive substances specified in the National Bureau of Standards Handbook 69. Numerical criteria established by the Basic Water Quality Standards are as follows:

1. Turbidity of other than natural origin shall not impart more than a 15 turbidity unit increase in the water when the turbidity of the receiving water is 150 units or less, or more than a 10% increase when the water turbidity is over 150 turbidity units.

2. Wastes of other than natural origin shall not be discharged in amounts which will result in dissolved oxygen content of less than 6 ppm at any time.

3. For streams where natural temperatures do not exceed 70° F, wastes of other than natural origin shall not be discharged in amounts which will result in an increase of more than 2° F over existing temperatures.

   For streams where natural temperatures exceed 70° F (21° C), wastes of other than natural origin shall not be discharged in amounts which will result in an increase of more than 4° F (2° C) over existing temperatures.

   Maximum allowable temperatures will be established for individual streams as data become available. As an

Table 16 - State of Montana Water Pollution Control Council - Water Quality Criter

SPECIFIC CRITERIA

Water Quality Criteria / Water Uses	Organisms of the Coliform Group by the most probable number (MPN) or equivalent membrane filter (MF) methods, during any consecutive 30-day period and using a representative number of samples, shall:	Dissolved Oxygen Milligrams per Liter (MG/L) No reduction shall be allowed below the listed minimum concentration.	pH Induced variation within listed range shall be less than 0.5 pH unit. Natural pH outside listed range shall be maintained without change. Natural pH above 7.0 shall be maintained above 7.0.	Turbidity Jackson Candle Units (JCU) Allowable increase to naturally occurring turbidity:	Temperature (°F) Allowable changes to naturally occurring water temperature:	Residues Oils. Floating solids and sludge deposits. Allowable increase above naturally occurring concentrations:
A- Closed. Water Supply for drinking, culinary, and food processing purposes; suitable for use after simple disinfection. Public Access and activities such as livestock grazing and timber harvest should be strictly controlled under conditions prescribed by the State Board of Health.	Average less than 50 per 100 milliliters (50/100 ML).	Not Applicable	No change in natural pH shall be allowed.	None.	None	None
A- Open. Water supply for drinking, culinary, and food processing purposes; suitable for use after simple disinfection and removal of naturally present impurities.	Average less than 50/100 ML where demonstrated to be the result of domestic sewage.	Not Applicable	6.5 to 8.5	Same as for use "A-Closed" above.	Not Applicable	None in sufficient quantities to adversely affect the use indicated.
B. Water supply for drinking, culinary, and food processing purposes; suitable for use with adequate treatment equal to coagulation, sedimentation, filtration, disinfection, and any additional treatment necessary to remove naturally present impurities.	Average less than 1000/100 ML, where demonstrated to be the result of domestic sewage, with not more than 20 percent of the samples exceeding this value.	Not Applicable	6.5 to 9.5	None in sufficient quantities to adversely affect established levels of treatment.	Not Applicable	None in sufficient quantities to adversely affect established levels of treatment.
C. Bathing, swimming, and recreation.	Same as for use "B" above	Not Applicable	Same as for use "B" above	10 JCU	Not Applicable	Same as for use "A-open" above
D-1. Growth and Propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers.	Same as for use "B" above	7MG/L	Same as for use "A-open" above	5 JCU	Increases: 32° to 67°: 2° maximum. Above 67°: 0.5° max. Decreases: Over 55° : 2° Per Hour. 55° to 32°: 2° Max. Provided that water temperatures must be below 40° during the winter season and above 44° during the summer season.	Same as for use "A-open" above
D-2. Growth and Marginal propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers.	Same as for sue "B" above	6 MG/L	6.5 yo 9.0	10 JCU	Same as for use "D-1" above	Same as for use "A-open" above
D-3. Growth and propagation of non-salmonid fishes and associated aquatic life, waterfowl and furbearers.	Same as for use "B" above	5 MG/L	Same as for use "B" above	10 JCU	Increases: 32° to 85°: 4° Maximum. Above 85°: 0.5° Max. Decreases: Above 55°: 2° Hr. 55° to 32°: 2° Maximum. Provided that water temperature must be below 40° during the winter season and above 44° during the summer season.	Same as for use "A-open" above
E. Agricultural water supply including irrigation, stock watering, and truck farming.	Same as for use "B" above	Not Applicable	Same as for use "B" above	None in sufficient quantities to adversely affect the use indicated.	Not Applicable	Same as for use "A-open" above
F. Industrial water supply (other than food processing).	Not Applicable	Not Applicable	Same as for use "B" above	Same as for use "B" above	None in sufficient quantities to adversely affect the use indicated.	Same as for use "A-open" above

Notes: 1) Qualitative and quantitative evaluation of water samples for comparison with these creieria should be made in accordance with procedures set forth in the *twelfth edition* of "*Standard Methods* for the Examination of Water and Wastewater", APEA, AWWA, and WPCF. 1965

2) Applicable after reasonable opportunity for discharges to mix with receiving waters as determined by the Montana Water Pollution Control Council.

3) Adopted by the Montana Water Pollut

Table 16 - State of Montana Water Pollution Control Council - Water Quality Criteria

SPECIFIC CRITERIA

Turbidity Jackson Candle Units (JCU) Allowable increase to naturally occurring turbidity:	Temperature (°F) Allowable changes to naturally occurring water temperature:	Residues Oils. Floating solids and sludge deposits. Allowable increase above naturally occurring concentrations:	Sediment or Settleable Solids Allowable increase above naturally occurring concentrations:	Toxic or other deleterious substances, pesticides and organic and inorganic materials including heavy metal compounds. (Exceptions for beneficial purposes may be authorized by the Montana Water Pollution Control Council and the Federal Water Pollution Control Administration)	Radioactivity (Limits listed shall include natural background)	'esthetic considerations not covered under other water quality criteria.
None.	None	None	None	None allowed in addition to concentrations naturally present.	No wastes shall be allowed which increase radioactivity above natural background.	No evidence of matter other than that naturally occurring.
Same as for use "A-Closed" above.	Not Applicable	None in sufficient quantities to adversely affect the use indicated.	None in sufficient quantities to adversely affect the use indicated.	Concentrations of chemical *constituents shall conform* with the 1962 U.S. Public Health Service drinking water standards. Induced variations within these standards shall be limited to an increase of not more than 10 percent of the concentration present in the receiving water.	Concentrations of radio*active materials shall* conform with the 1962 U.S. Public Health Service drinking water standards.	No evidence of matter other than that naturally occurring, except, *real color* shall not be increased more than two units above naturally occurring concentrations.
None in sufficient quantities to adversely affect established levels of treatment.	Not Applicable	None in sufficient quantities to adversely affect established levels of treatment.	None in sufficient quantities to adversely affect established levels of treatment.	Concentrations of chemical constituents shall conform with the 1962 U.S. Public Health Service drinking water standards after conventional treatment.	Same as for use "A- pen" above	No wastes (including Phenolic compounds and visible oils), offensive to the senses of sight, touch, smell, or taste, not attributable to natural causes, shall be allowed.
10 JCU	Not Applicable	Same as for use "A-open" above	Same as for use "A-open" above	Concentrations of chemical constituents shall be maintained below levels known to be (or demonstrated to be) of public health significance.	Same as for use "A-open" above	Same as for use "B" above
5 JCU	Increases: 32° to 67°: 2° maximum. Above 67°: 0.5° max. Decreases: Over 55° : 2° Per Hour. 55° to 32°: 2° Max. Provided that water temperatures must be below 40° during the winter season and above 44° during the summer season.	Same as for use "A-open" above	Same as for use "A-open" above	Maximum allowable concentrations shall be less than acute or chronic problem levels as revealed by bioassay or other appropriate methods. In no case shall the following be exceeded: one-tenth of the four-day, median tolerance limit (TLm *96) for short residual* materials and one-hundredth (0.01) of the TLm 96 for pesticides and organic materials exibiting a residual life exceeding 30 days in water.	Same as for use "A-open" above, except where concentrations factors of aquatic flora and fauna exceed the recommended reduction factors, then maximum permissible limits shall be reduced below acute or chronic *problem levels.*	No wastes (including phenolic compounds and visible oils), offensive to the senses of sight, touch, smell, or taste, not attributable to natural causes, shall be allowed. No excess nutrients which cause nuisance aquatic growths. Taste and odor causing materials shall not exceed levels which cause tainting of the flesh of edible *species. Real color shall* not exceed five units above naturally occurring color.
10 JCU	Same as for use "D-1" above	Same as for use "A-open" above	Same as for use "A-open" above	Same as for use "D-1" above	Same as for use "D-1" above	Same as for use "D-1" above
10 JCU	Increases: 32° to 85°: 4° Maximum. Above 85°: 0.5° Max. Decreases: *Above 55°: 2° Hr.* 55° to 32°: 2° Maximum. Provided that water temperature must be below 40° during the winter season and above 44° during the summer season.	Same as for use "A-open" above	Same as for use "A-open" above	Same as for use "D-1" above	Same as for use "D-1" above	Same as for use "D-1"above
None in sufficient quantities to adversely affect the use indicated.	Not Applicable	Same as for use "A-open" above	Same as for use "A-open" above	Concentrations shall be less than those demonstrated to be deleterious to livestock or plants or their subsequent consumption by humans.	Same as for use "A-open" above	Water shall be maintained in a condition not offensive to the senses of sight and smell.
Same as for use "B" above	None in sufficient quantities to adversely affect the use indicated.	Same as for use "A-open" above	Same as for use "B" above	None in sufficient quan*tities to adversely affect* the use indicated.	Same as for use "A-open" above	Same as for use "E" above

pportunity for discharges to mix with
y the Montana Water Pollution Control

3) Adopted by the Montana Water Pollution Control Council, June 5,1967.

interim policy, the maximum allowable stream temperatures will be the maximum daily stream temperatures plus the allowable rise; provided that this temperature is not lethal to existing fish life, which is considered to be 78° F (26° C) in the case of cold water fish.

4. Wastes of other than natural origin shall not affect the pH of the receiving water beyond the following limits:

   a. On those streams where water quality data are inadequate, the range for pH shall be 6.5 to 8.5.

   b. On those streams where water quality data are adequate, a pH range within natural variations can be established in the supplementary standards.

5. During the recreation season (May 1 through September 30), wastes or substances of other than natural origin shall not be discharged into waters designated as having limited body contact use which will cause organisms of the fecal coliform group to exceed the following limits.

   While sample data are accumulated no individual samples shall exceed the 95% confidence limit of the historical average; provided that in no case will the geometric mean of the last five consecutive samples exceed 2000 per 100 ml (Most Probable Number), whichever is the least.

More specific information on a particular state's water quality standards can be obtained from the Federal Water Quality Administration or the respective state pollution control agency.

MEANS TO SATISFY DEMANDS

Reduction of pollution loads to receiving streams can be accomplished either by reducing the amounts of wastes generated or by raising the level of treatment of the wastes. The amounts of wastes generated can be controlled to some extent by regulation, by changes in practices such as by-product recovery in an industrial process, or by cost incentives, using a system of charges based on quantities of pollutants discharged. These approaches have only limited possibilities, however, and some degree of waste water treatment is almost always required. Detailed planning and adequate financing are required so as to prevent potential water pollution which would otherwise result from increasing waste loadings.

No waste water treatment process can remove <u>all</u> pollutants from a waste stream, and the cost of treatment increases greatly with increased demands for a high quality effluent. In addition, not all waste waters are easily controllable or, in some cases,

identifiable. Natural runoff from urban and rural areas contains appreciable quantities of pollutants which enter the streams from a wide area as well as from storm drains. Most of the drainage from agricultural land cannot be fully controlled at the present time.

Some pollutants will always be discharged, and we must rely heavily on the dilution capability of the receiving waters for maintenance of quality.

The increasing rate of production of industrial and domestic waste waters has prompted scientists and engineers to investigate methods of renovation which offer alternatives to disposal in surface water bodies. Reuse of effluent for irrigation, fertilization and ground-water recharge is among the techniques which have received much attention during the past several years.

The implementation and enforcement plan of the water quality standards for public waters requires that all municipalities and industries provide a high level of treatment. For those not already providing secondary treatment or equivalent, such treatment must be employed by July 1972.

Waste Treatment

Future Waste Discharges

Municipal Present trends and policies in water pollution regulation as well as basic knowledge of the characteristics of waste water effluents indicate that the minimum acceptable degree of treatment for municipal waste water is 85 to 90 percent removal of oxidizable organics. Based on 85 percent organic removal in 1980 and 90 percent in 2000 and 2020, and the raw waste projections presented earlier, the projected municipal waste loadings to be discharged to the waters in the region are shown in table 17. In situations where minimization of BOD does not maintain adequate quality, a tertiary treatment process will be necessary.

Ocean outfalls should be considered in preference to discharging into estuaries. Coastal communities and industries can maintain higher quality waters in the estuaries by using ocean disposal.

Industrial Industrial waste must receive the same degree of treatment as municipal waste before discharge into the region's water courses.

Table 17 - Projected Municipal Organic Discharges
Columbia-North Pacific Region

Subregion	1980	2000	2020
		(1,000's P.E.)	
1	93.1	88.5	120.4
2	36.3	36.3	49.5
3	24.8	23.7	33.1
4	39.8	42.0	61.1
5	39.9	40.6	57.5
6	23.1	21.1	26.8
7	28.6	27.2	36.4
8	29.4	30.6	44.8
9	287.4	270.0	410.4
10	55.1	51.1	68.5
11	477.5	511.8	820.8
12	1.3	1.2	1.6
Total C-NP Region	1,136.3	1,144.1	1,730.9

Based on the raw organic waste projections presented earlier and 85 percent organic removal in 1980 and 90 percent removal thereafter, the projected industrial organic waste discharges reaching the streams are shown in table 18.

The strength of industrial waste waters can be reduced in a variety of ways: (1) by altering manufacturing processes to decrease the volume and concentration of waste waters, (2) by developing means for the recovery of useful and marketable by-products from the waste waters, and (3) by treatment and reuse of process waters within the plant before discharge into the receiving waters. All industrial processes should be operated in such a manner that the spent waters will contain the minimum amount of material before leaving the plant. Pollution loads can also be reduced by employing dry processes when the technology is available in lieu of wet methods requiring large volumes of water. Another possible way is to substitute chemical compounds that are less toxic and not as undesirable in the waste stream.

The discharge of industrial waste waters into municipal sewerage systems may be advantageous (1) when the waste waters become more amenable to treatment after they have been mixed with domestic sewage; (2) when treatment of combined wastes is more economical because of the increased size of the operation; and (3) when treatment of the combined wastes is more effective and economical because of the technical and sanitary supervision available in municipal works.

Table 18 - Projected Industrial Organic Waste Discharges
Columbia-North Pacific Region

Subregion	1980	2000 (1,000's P.E.)	2020
1	118.8	97.5	110.5
2	480.9	509.7	771.7
3	180.2	173.2	250.2
4	682.0	671.0	851.9
5	212.7	235.5	352.1
6	93.9	73.8	83.1
7	304.6	267.3	347.2
8	706.4	686.1	754.8
9	621.3	595.5	765.2
10	1,170.0	939.1	1,029.0
11	2,251.2	1,645.4	1,888.6
12	-	-	-
Total C-NP Region	6,822.0	5,894.1	7,204.3

The authorities should be empowered: (1) to specify the manner of waste water discharge into sewerage systems; (2) to exclude objectionable or dangerous wastes from sewerage systems; (3) to require pretreatment of industrial waste waters to a level that would be compatible with municipal sewage and amenable to centralized treatment; and (4) to determine, negotiate, and levy appropriate charges upon industries for acceptance and disposal of water-carried industrial wastes.

Vegetable- and fruit-processing waste treatment and disposal are peculiarly difficult because of the seasonal nature of the industry and because of the shifting from one vegetable or fruit to another as the season advances. Screening and lagooning or land disposal by irrigation are methods used most often. Screenings are buried, burned, spread on land, or used for feed. (About 25 percent of the liquid can be stored during the winter in order to dilute and seed the next year's batch.) Water is lost from the lagoons by evaporation and seepage in addition to being discharged into receiving waters during spring freshets.

Rural-Domestic The rural-domestic waste production is scattered and expected to decrease during the projection period. In general, septic tanks and some type of subsurface drainage are used for waste disposal and the actual waste load reaching waterways is not expected to be large. However, ground-water pollution may be a problem in some areas. The rural-domestic waste problems are discussed in the subregional portion of this report.

Other Pollution Control Practices

Irrigation

Improved irrigation efficiencies would result in the conservation of water and a decrease in the volume of return flows. This can be accomplished by replacement of old worn systems which have high water losses and by utilizing more efficient application techniques such as found in modern sprinkler systems. However, irrigation water requirements should be adequate to leach the applied salts from the soil profile.

Other Land Uses

Sediment, the product of erosion, is agriculture's most significant pollution problem. Most of the pesticides and phosphates are attached to the soil particles and carried to the stream. Measures for the control of erosion frequently are effective in reducing pollution from the source; however, nutrient-poor sediments from subsoils will tend to deactivate the soluble phosphate.

Watershed protection and rehabilitation practices required to satisfy needs are outlined in detail in the Land Measures and Watershed Protection Appendix.

Watershed research has shown that land cover is the major deterrent to sediment delivery into tributary streams. Improved technology must be employed for stabilizing and revegetating gullies, overgrazed rangelands, forest burns, and badly disturbed construction sites. Proper logging methods and improved construction practices on forest roads can greatly reduce sediment delivery from forest operations. The abatement of wild fires has made a major reduction in erosion. Regardless of soil type, a well-managed conservation program is necessary for erosion control.

Agricultural chemicals, pesticides, and fertilizers will continue to be used, and a much stronger program for control is needed. Improved registration, better instruction use, and better information on using pesticides will reduce the concentration in our waters.

An alternate method of pest control is by use of less persistent and faster degradable pesticides, by use of parasite predators and microbiological pathogens, and by insect sterilization with radiation and chemicals. Improved farming practices such as fall plowing kill certain pests and eliminate the use of certain harmful pesticides, but the land is further exposed to erosion.

Agricultural Animals

The trend towards large-scale, concentrated livestock and poultry enterprises will increase the potential for localized incidences of severe water pollution caused by agricultural animal wastes. Water quality problems from this source can normally be minimized through the use of good land management practices.

Enactment of legislation and establishment of rules and regulations to control wastes from large confinement-type operations such as poultry farms or feedlots are essential to prevent water quality degradation from this source. Generally, an operation of this type should be located well away from a watercourse or an area of shallow ground-water depth. In addition, some degree of treatment of the wastes produced will be required, depending on the individual circumstances. Some methods of disposing of animal wastes are: lagoon treatment, fluidizing and spraying on fields, dehydration, composting, and selling for fertilizer.

Navigation

The problems resulting from accidental spills of deleterious materials can be extremely serious because they occur irregularly and on an unplanned basis. Management of accidental spills must be based on preventing, or at least minimizing, their occurrence, and for those spills which do occur it is possible, by containment, to minimize their adverse effects. Attention should be directed also to consideration of a system of charges that would provide an incentive for the discharger to take positive steps to minimize accidental spills.

Minimum Flow Requirements

Since waste treatment cannot be applied to non-collectible wastes and does not economically remove all contaminants from collectible wastes, a certain amount of streamflow is necessary for dilution and assimilation of residual wastes reaching the streams. Maintenance of base flows for water quality control purposes is the key to any program for present and future water quality management. Even if wastes are provided complete treatment, including removal of nutrients and solids, minimum streamflows will still be required to assimilate organic loads from uncontrollable sources. The flows needed for this purpose have been computed for critical stream reaches in the region. These flows are presented in the applicable subregional writeup.

Where feasible, consideration should be given to transporting waste treatment plant effluent to the larger stream in situations where communities are located near the confluence of streams. Where feasible, ocean outfalls should be used in preference to discharging into estuaries and fresh water streams.

Spray disposal is particularly useful when manufacturing operations reach their peak during the summer and fall or when evapotranspiration is high and the water table is low.

Analogous to streamflow augmentation is waste water storage with controlled releases. This method is not considered as a substitute for waste water treatment, but as a means to level out abnormal peak flows and as an interim solution. The waste water is scheduled for release when the condition of the receiving water will be least affected. In addition, the strength of the waste water is further reduced from sedimentation during storage.

Treatment Costs

A set of curves showing the total capital costs and the actual operation and maintenance costs for various levels of treatment of municipal wastes is presented in figures 4 and 5, respectively. Table 19 presents the total estimated costs for municipal waste treatment for each subregion.

The costs were predicted based upon the following assumptions:

1. Eighty-five percent treatment (BOD removal) requires a trickling filter plant with disinfection.

2. Ninety percent treatment requires an activated sludge plant with disinfection.

3. Ninety-five percent treatment requires an activated sludge process, followed by coagulation, sedimentation, and disinfection.

4. Costs are based on 1967 data and updated by 1.10 to represent January 1969 costs.

5. Costs are based on average annual flows and converted to population equivalents. The projected per capita flow is 165 gpcd by 1980, 175 gpcd by 2000 and 185 gpcd by 2020. The 2020 flows of 185 gpcd were used to develop the curves.

6. A new treatment facility will be required in 1980, 2000, and 2020. In 1990 and 2010 the existing facility will be enlarged to handle 2000 and 2020 predicted loads, respectively.

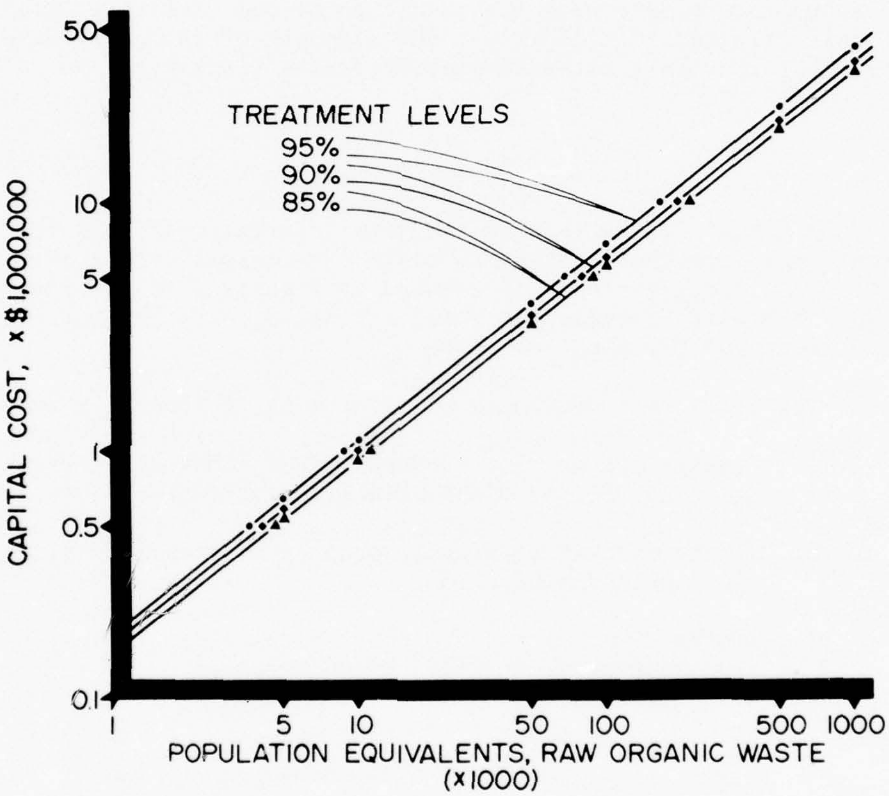


FIGURE 4. Capital Cost of Municipal Sewage Treatment Plants

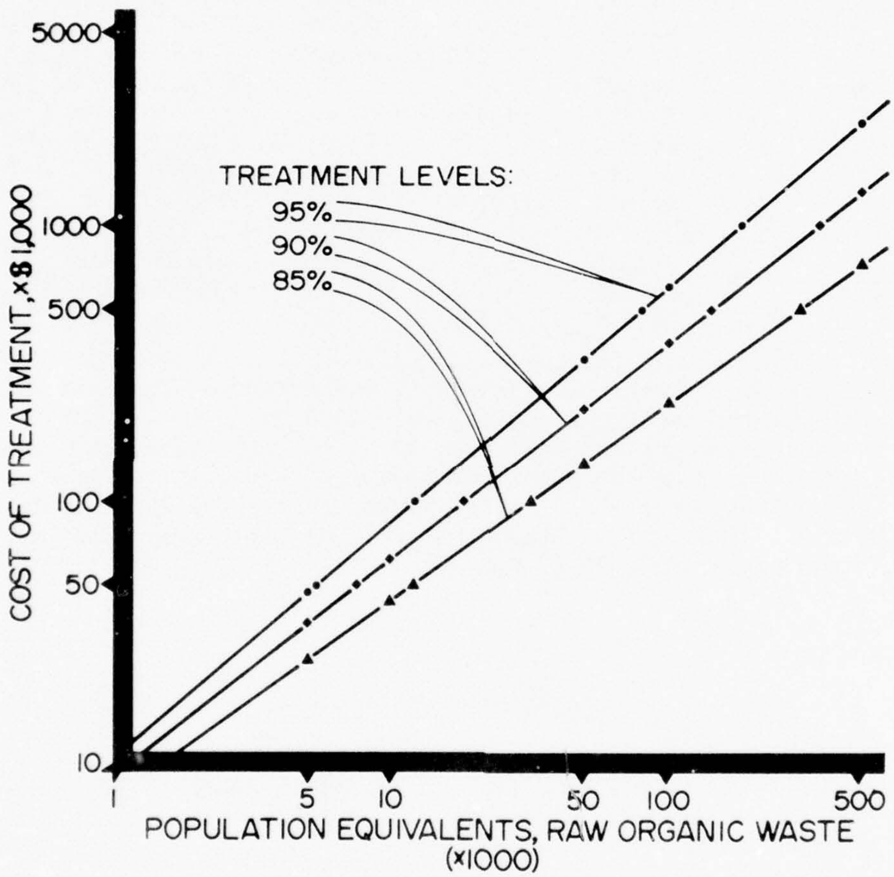


FIGURE 5. Annual Operation and Maintenance Costs of Municipal Sewage Treatment Plants

Table 19 - Present and Projected Municipal Waste Treatment Costs
Columbia-North Pacific Region 1/ 2/ 3/

Subregion	1980	1990	2000	2010	2020
			Thousands of Dollars		
1	76,966	39,799	99,110	50,102	126,125
2	29,909	16,815	41,176	22,957	56,872
3	27,359	14,304	35,647	17,667	45,262
4	39,622	23,046	55,695	30,417	78,295
5	35,278	19,673	47,866	25,155	64,030
6	24,089	12,796	30,378	14,820	37,009
7	31,459	16,197	40,212	20,741	51,967
8	31,602	15,734	39,939	19,804	49,755
9	132,378	81,979	200,810	121,325	301,718
10	64,226	35,681	86,497	45,925	114,701
11	173,431	98,165	269,135	165,341	393,974
12	2,375	1,059	2,695	1,183	3,136

1/ Derived from "Cost of Conventional and Advanced Treatment of Wastewaters," by Robert Smith, July 1968.
2/ Values are amount expended over 10 years. They include capital construction costs and operation and maintenance costs.
3/ It was presumed that all plants were constructed in 1960 and have a 20-year life. Thus, they will be completely replaced in the years 1980, 2000, and 2020.

Management Practices

Clearly defined working arrangements, as authorized by Executive Order 11288, need to be developed between all agencies engaged in water resource management and in land management affecting water quality. Detailed planning and adequate financing are required so as to prevent any water quality degradation as a result of flow alteration, increased waste loadings, or other basin developments. If flow regulation for water quality control is authorized in Federal storage projects, cooperative relationships between all concerned agencies will be essential to insure that all competing uses of stored water are recognized and that allocations are made for these uses.

LOCATION MAP

SUBREGION 1

S U B R E G I O N 1

C L A R K F O R K - K O O T E N A I - S P O K A N E

INTRODUCTION

The Clark Fork-Kootenai-Spokane Subregion (figure 6) drains an area of 36,360 square miles in Montana, Idaho, and Washington. The subregion is bounded on the north by the Canadian line, on the east by the Continental Divide, and on the west and south by several drainage divides.

In general, the area is characterized by cold, wet winters and hot, dry summers; but the climate varies greatly with elevation and location. Annual precipitation varies from 10 to 70 inches. Relatively dry belts exist in the rain shadows of the mountain ranges, with greater precipitation on the western, windward slopes.

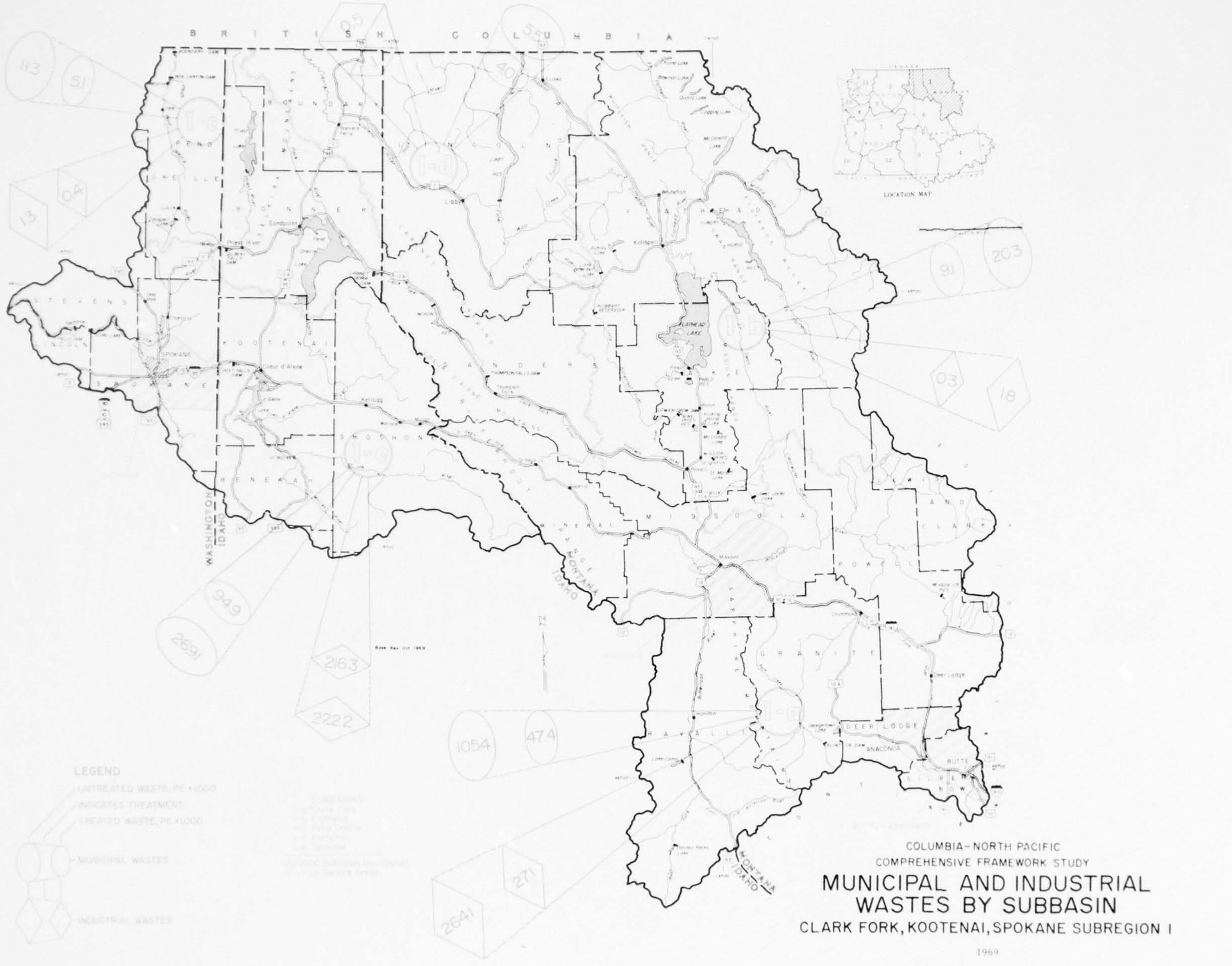
Mining, forestry, agriculture, and recreation are the principal areas of employment. The subregion has outstanding mineral resources that have been well developed, and contains large reserves of important minerals. The forest products industry utilizes the conifer forests covering a large part of the area for production of pulp and paper, lumber, and plywood. Agricultural pursuits are oriented toward livestock raising. Recreation development is becoming increasingly more important to the economy. Glacier National Park and nearly 10 million acres of other Federal land (mainly forest land), along with numerous lakes and rivers, provide excellent opportunities for outdoor recreation.

The 1965 population was about 595,100, the third highest subregional total. Most of the people are concentrated in the major towns, with large areas only sparsely populated.

The subregion is divided into the Clark Fork, Flathead, Pend Oreille, Kootenai, and Spokane Subbasins. The major service areas are the Butte-Anaconda, Missoula, and Spokane areas.

PRESENT STATUS

Municipalities and industries are the most important pollution sources in the subregion, contributing suspended and settleable organic materials to waterways. Figure 6 presents a



COLUMBIA–NORTH PACIFIC
COMPREHENSIVE FRAMEWORK STUDY

MUNICIPAL AND INDUSTRIAL WASTES BY SUBBASIN

CLARK FORK, KOOTENAI, SPOKANE SUBREGION I

1969

FIGURE 6

summary of municipal and industrial organic waste generation and discharge for each major subbasin. The pulp and paper industry is the largest waste source. Although not reflected in organic waste loadings, the mining and milling of primary metals introduce biologically toxic concentrations of heavy metals and high sediment concentrations to streams. The rural-domestic population, agricultural animals, and land use are also important pollution sources. However, the magnitude and impact of wastes from these sources are not readily identifiable.

Generally, the surface and ground waters of the subregion are of excellent quality. The only exceptions are usually local bacterial contamination of streams below municipalities and sediment problems below mining operations.

Stream Characteristics

The principal streams in Subregion 1 are the Kootenai, Spokane, Flathead, Clark Fork, and Pend Oreille Rivers. All of these are fed primarily by snowmelt rivers with additional runoff contributed by rainfall. Most rivers are controlled by storage for power and irrigation, affording in some instances an opportunity for recreation.

Average annual runoff from the subregion amounts to about 35.1 million acre-feet, of which about 8.9 million acre-feet originate in Canada.

Surface-Water Hydrology

Seasonal distribution of streamflow is characterized by peak flows during May and June--a direct result of precipitation and melting snow. Average flows for these 2 months are about three times the average annual flows. April and July flows are about equal to, or a little above, average annual flows. The other 8 months are characterized by low flows, approximately one-half of the average annual flows. Average annual flows by month, and mean annual flows for selected stations on major rivers and tributaries are presented in table 20.

Table 20 - Average Monthly Discharge, Subregion I (12)

Stream Location	Jan.	Feb.	March	April	May	June	July (CFS)	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
Clark Fork Subbasin													
Blackfoot River near Bonner, Mont.	524	524	642	1,646	4,547	4,706	1,871	892	618	589	626	571	1,479
Clark Fork River above Missoula, Mont.	1,209	1,317	1,721	3,620	7,816	7,719	2,869	1,366	1,217	1,439	1482	1,356	2,761
Clark Fork River below Missoula, Mont.	2,080	2,242	2,953	6,280	14,857	15,362	5,366	2,034	1,946	2,589	2,666	2,423	5,066
Clark Fork River near Plains, Mont.	13,983	10,272	11,197	20,259	43,057	40,623	18,536	7,281	8,641	15,297	16,843	13,947	18,328
Clark Fork River near Cabinet, Idaho	15,275	12,846	13,384	27,535	44,129	44,472	21,497	8,586	9,445	16,166	17,846	15,490	20,889
Flathead Subbasin													
Flathead River at Flathead, B. C.	184	155	176	968	3,586	2,826	919	362	273	354	329	228	863
Flathead River near Columbia Falls, Montana	698	688	753	3,265	10,516	9,277	3,802	1,499	1,045	1,176	1,115	894	2,894
South Fork Flathead River near Columbia Falls, Montana	1,238	2,083	1,554	7,988	1,859	2,389	1,768	1,229	2,054	5,747	7,234	4,965	3,342
Flathead River at Columbia Falls, Montana	2,986	3,745	3,357	16,175	23,613	22,281	9,771	4,133	4,126	8,083	9,513	6,845	9,552
Flathead River near Polson, Montana	10,625	6,544	6,601	10,593	22,059	19,879	10,812	3,999	5,648	11,367	12,721	10,025	10,906
Pend Oreille Subbasin													
Pend Oreille River at Newport, Wash.	17,679	15,181	16,487	32,079	47,252	49,634	23,055	9,069	10,997	22,147	24,837	24,769	24,457
Pend Oreille River near Metaline Falls, Washington	18,412	16,294	17,783	34,869	49,056	53,080	26,385	10,182	10,346	22,631	25,527	25,504	25,839
Kootenai Subbasin													
Kootenai River at Newgate, B. C.	2,562	2,498	2,680	7,334	26,416	33,619	18,524	8,072	5,880	5,180	4,076	3,073	9,993
Kootenai River at Libby, Montana	13,452	21,781	20,528	7,919	14,885	7,090	9,495	6,818	6,610	6,761	10,311	12,027	11,473
Kootenai River at Leonia, Idaho	14,184	22,580	21,530	11,761	21,812	11,171	10,736	7,380	6,998	7,310	11,044	12,833	13,277
Moyle River at Eileen, Idaho	241	257	371	1,808	3,700	2,145	574	176	135	224	294	318	854
Kootenai River at Porthill, Idaho	14,826	23,052	22,470	15,474	29,071	17,504	13,124	7,865	7,275	7,849	11,791	13,640	15,328
Spokane Subbasin													
Spokane River at Spokane, Wash.	5,249	5,465	7,453	15,035	19,039	9,768	2,592	1,490	1,533	2,088	3,092	5,020	6,485
Coeur d'Alene River at Cataldo, Idaho	1,654	1,961	2,981	7,652	7,193	2,596	902	468	391	554	1,144	2,152	2,471

From the standpoint of waste discharge control, the low-flow months of August, September, and October are the most important. In most of the subregion, August is the critical month. One-in-ten-year low flow is the selected recurrence frequency designated to describe critical low flows. These data for selected stations are summarized in table 21.

Table 21 - One-in-Ten-Year Low Flows, Subregion 1 (12)

Stream and Location	One-in-Ten-Year Low Flow (cfs) 1/
Clark Fork Subbasin	
Blackfoot River near Bonner, Montana	300
Clark Fork River above Missoula, Montana	710
Clark Fork River below Missoula, Montana	1,050
Clark Fork River near Plains, Montana	4,000
Clark Fork River near Cabinet, Idaho	5,300
Flathead Subbasin	
Flathead River at Flathead, B.C.	95
Flathead River near Columbia Falls, Montana	370
South Fork Flathead R. near Columbia Falls, Mont.	280
Flathead River at Columbia Falls, Montana	1,100
Flathead River at Polson, Montana	1,900
Pend Oreille Subbasin	
Pend Oreille River at Newport, Washington	5,100
Pend Oreille R. near Metaline Falls, Wash.	5,800
Kootenai Subbasin	
Kootenai River at Newgate, B.C.	1,600
Kootenai River at Libby, Montana	2,800
Kootenai River at Leonia, Idaho	3,400
Moyie River at Eileen, Idaho	59
Kootenai River at Porthill, Idaho	4,100
Spokane Subbasin	
Spokane River at Spokane, Washington	1,030
Coeur d'Alene River at Cataldo, Idaho	220

1/ Period of 1 month.

Impoundments and Stream Regulation

Major impoundments include Flathead, Pend Oreille, Coeur d'Alene, and Priest Lakes, and Hungry Horse, Libby, and Noxon Rapids Reservoirs. In general, operation of impoundments is designed to provide regulation primarily for the authorized purposes of flood control, irrigation, power, navigation, and fish and wildlife enhancement.

Generally, examination of impoundments with regard to water quality has been very limited. However, the high level of development that has been imposed upon the waters of the subregion makes the effects of impoundments an important feature of the water quality control situation of the subregion.

The most severe water quality problem associated with impoundments is at and below Long Lake Dam. Thermal stratification, coupled with nutrient and organic loads in the vicinity of Spokane, has resulted in oxygen depletion in the bottom layers of Long Lake during the summer and fall months. Abundant quantities of nutrients stimulate algal growth in Long Lake. The settling and decomposition of dead algal cells in the bottom layers of the lake add to the depletion of oxygen.

Ground-Water Characteristics

Large supplies of ground water are available in certain areas of the Clark Fork-Kootenai-Spokane Subregion. The largest is in the Spokane Subbasin, where a substantial portion of the ground water is underflow from Lake Pend Oreille, which moves beneath Rathdrum Prairie in Idaho and enters the Spokane Valley. Wells with specific capacities of a few hundred to several thousand gpm per foot are common. Other areas with moderate to large yields obtained from wells include parts of Bitterroot, Missoula, Deer Lodge, Divide Creek, Kootenai, and Flathead Valleys.

Ground-water reservoirs, although used appreciably only in the Spokane area, can supply large yields. High quality surface water, available in most of the subregion, has minimized the development of ground-water resources at present. A rough estimate indicates that the magnitude of the available ground-water supply, is many million acre-feet.

The general chemical quality of ground water is excellent. Water from alluvial and glacial deposits, furnishing most of the large well supplies, is chacterized by dissolved solids of less than 200 mg/l; total hardness of 80 to 150 mg/l; low fluoride concentrations; and no iron problems. Sedimentary and volcanic aquifer formations generally exhibit dissolved solids of less than 250 mg/l; total hardness 50 to 110 mg/l; fluoride 0.2 to 0.8 mg/l; silica generally 40 to 50 mg/l; and iron may be a problem in a few wells.

In general, there are no detrimental or hazardous constituents that would affect the utility of the water for domestic, industrial, or irrigation use. However, some concern has been voiced in the Spokane and Missoula areas about the possible contamination of ground water by ground waste disposal practices of homes and industries in the unincorporated areas surrounding these service areas.

Pollution Sources

Industrial waste production and treatment, in population equivalents, in the Clark Fork-Kootenai-Spokane Subregion are summarized for each subbasin in table 22.

Table 22 - Inventory of Municipal and Industrial Waste Treatment, Subregion 1[1/]

	Municipal Waste Treatment					Industrial Waste Treatment				
	Primary	Secondary	Lagoons	Other	Total	Pulp and Paper	Lumber & Wood Products	Food Products	Misc.	Total
Clark Fork Subbasin										
Number of Facilities	1	3	7	6	17	1	3	5	10	19
Population Served	30,000	49,700	11,650	13,500	104,850	250,000[2/]	10,600	5,500		
P.E. Untreated	30,000	49,700	12,150	13,500	105,350	20,000	5,000	2,130	0	264,100
P.E. Treated	18,000	7,415	8,550	13,400	47,365	92	53	39	0	27,130
% Removal Efficiency	40	86	30	1	55				-	90
Flathead Subbasin										
Number of Facilities	1	2	4	2	9	0	2	.	1	4
Population Served	11,500	800	6,800	1,200	20,300					
P.E. Untreated	11,500	800	6,800	1,200	20,300	0	1,500	300	0	1,800
P.E. Treated	7,500	120	1,500	0	9,120	0	0	300	0	300
% Removal Efficiency	35	85	78	100	55	-	100	0	-	83
Pend Oreille Subbasin										
Number of Facilities	3	0	4	0	7	0	1	1	3	5
Population Served	9,400	0	1,900	0	11,300					
P.E. Untreated	9,400	0	1,900	0	11,300	0	1,000	300	40	1,540
P.E. Treated	5,080	0	20	0	5,100	0	340	0	40	380
% Removal Efficiency	46	-	99	-	45	-	66	100	0	72
Kootenai Subbasin										
Number of Facilities	2	0	0	1	3	1	0	0	2	3
Population Served	4,000	0	0	1,500	5,500	-				
P.E. Untreated	4,000	0	0	1,500	5,500	500	0	0	0	500
P.E. Treated	2,650	0	0	1,380	4,030	50	0	0	0	50
% Removal Efficiency	34	-	-	8	27	90	-	-	-	90
Spokane Subbasin										
Number of Facilities	1	11	11	10	33	1	0	2	12	15
Population Served	160,000	19,500	17,650	9,280	206,430					
P.E. Untreated	210,000	29,300	19,850	9,980	269,130	215,000	0	7,200	0	222,200
P.E. Treated	80,000	3,305	1,820	9,800	94,925	210,000	0	6,300	0	216,300
% Removal Efficiency	62	89	91	2	65	2	-	13	-	3
Total										
Number of Facilities	8	16	26	19	69	3	6	9	28[3/]	46
Population Served	214,900	70,000	38,000	25,480	348,380					
P.E. Produced	264,900	79,800	40,700	26,180	411,580	465,500	13,100	11,300	40	489,940
P.E. Discharged	113,230	10,840	11,890	24,580	160,540	230,050	5,340	8,730	40	244,160
% Removal Efficiency	57	86	71	6	61	51	59	23	0	50

1/ FWPCA inventory of Municipal and Industrial Wastes, Clark Fork-Kootenai-Spokane, Subregion 1965.
2/ Wastes held during low river flows. Up to 420,000 P.E. discharged during high flows.
3/ Includes inorganic wastes from mining operations.

At present, municipalities and industries produce organic wastes equivalent to those from a population of about 901,500 persons. Of this total, 52 percent is generated by the pulp and paper industry, 46 percent by municipalities, and the remaining two percent by the food-processing, lumber and wood products, and miscellaneous industries.

Waste treatment and other means of waste reduction decrease the total organic load to the subregion's surface waters about 55 percent, so that only 404,700 population equivalents actually reach waterways. Of this total, 160,540 PE are released by municipalities, and 244,160 PE are discharged by industries. In

addition, the primary metals industry discharges approximately 27 million gallons of inorganic wastes daily, which may contain high sediment concentrations and toxic materials.

Other sources of pollution include wastes from the rural population, land use, domestic animals, irrigation, recreation, and natural sources.

Municipalities

Clark Fork Subbasin Of the 17 municipal waste sources in the Clark Fork Subbasin, 14 provide conventional waste treatment facilities. An average reduction in biochemical oxygen demand of only 55 percent is accomplished by the municipalities, resulting in an organic waste loading to streams of approximately 47,000 population equivalents.

The Butte-Anaconda Service Area accounts for 62,450 PE, or 70 percent of the total municipal waste load in the subbasin. The City of Anaconda presently provides no waste treatment, resulting in 19,000 PE of sewage being discharged to Silver Bow Creek. However, the entire flow of the stream is treated in large lagoons in the vicinity of Warm Springs. These lagoons provide very efficient treatment, so that an organic loading of only about 4,300 PE is discharged to the Clark Fork River. The municipalities in the Butte-Anaconda Service Area below Warm Springs provide treatment by oxidation lagoons or secondary plants. They discharge a combined organic load of 1,450 PE to the Clark Fork River. The Montana State Tuberculosis Hospital at Galen does not presently provide disinfection of its secondary waste effluent to the Clark Fork River; however, chlorination facilities will be required before January 1, 1970, by the Montana Water Pollution Control Council.

The municipal population of the Missoula Service Area is provided with primary treatment of its wastes. An organic loading of 18,000 PE is discharged to the Clark Fork River from the facility. The Montana Standards call for secondary treatment at Missoula by 1972.

All communities in the Bitterroot Valley provide treatment of domestic wastes by oxidation lagoons or primary treatment plants. The Hamilton plant receives high flows from the Bitterroot Cannery for 1 month in the summer. This results in an overloading of present primary treatment facilities. The State of Montana anticipates early expansion of the present facilities at Hamilton, with secondary treatment to be provided by 1972.

Flathead Subbasin Waste collection and treatment facilities serve 20,300 persons, or 41 percent of the Flathead Subbasin population. In general, municipalities provide an adequate level of waste treatment, so that only about 9,120 PE are released to waterways.

The City of Kalispell discharges about 7,500 PE to Ashley Creek from its primary facility. This represents about 82 percent of the total municipal waste loading in the Flathead Subbasin, and has resulted in serious pollution problems in Ashley Creek. The Montana Water Quality Standards call for secondary treatment at Kalispell by January 1, 1972.

Other communities generally have secondary treatment facilities or oxidation lagoons. However, Apgar and West Glacier utilize septic tanks and subsurface drainage fields. The City of Columbia Falls does not provide a sewer system or treatment plant. Domestic wastes are disposed of by individual subsurface application.

Pend Oreille Subbasin Only 11,300 persons, or 58 percent of the Pend Oreille Subbasin population, are served by municipal waste collection and treatment facilities. The municipal population contributes about 5,100 PE to the Pend Oreille River and Pend Oreille Lake. The three largest communities (Sandpoint, Newport, and Priest River) have primary waste treatment facilities. Most other communities in the area utilize nonoverflow lagoons, thus contributing little to the pollution of waterways.

The cities of Newport, Washington, and Priest River, Idaho, discharge organic waste loadings of 1,000 and 480 PE, respectively, to the Pend Oreille River; and the City of Sandpoint, Idaho, discharges 3,600 PE to Pend Oreille Lake. The Washington Water Quality Standards call for secondary treatment at Newport during 1972. The Idaho Water Quality Standards list Priest River and Sandpoint as in need of secondary treatment during 1971.

Kootenai Subbasin Approximately 5,500 persons, or only 23 percent of the Kootenai Subbasin population, are served by municipal waste collection and treatment systems. The cities of Eureka and Libby, Montana, provide primary treatment, and Bonners Ferry, Idaho, has septic tanks, which are scheduled to be replaced with a secondary treatment facility. The remaining population in the Kootenai Subbasin is scattered in rural areas or in small communities which do not have sewage collection systems.

Eureka discharges an organic load of 700 PE to Tobacco River, and Bonners Ferry and Libby discharge 1,380 and 1,950 PE, respectively, to the Kootenai River.

Spokane Subbasin Approximately 206,430 persons, or 58 percent of the Spokane Subbasin, are served by municipal waste collection systems. The municipal waste treatment inventory includes 11 secondary treatment facilities, one primary treatment plant, 11 lagoons, and 10 municipalities which do not have any form of conventional waste treatment. The average reduction in the biochemical oxygen demand by waste treatment is 65 percent.

The major municipal waste discharge is in the Spokane Service Area, which accounts for nearly 90 percent of the subbasin's municipal population and waste discharge. Most major municipalities in the service area provide either secondary treatment or nonoverflow lagoons, except the City of Spokane, which has primary treatment. The Washington Water Quality Standards call for secondary treatment of Spokane municipal wastes by June 30, 1972. The City of Spokane presently discharges about 80,000 PE to the Spokane River. In addition, there are areas in the Spokane vicinity where combined sewers and scattered raw waste discharges now exist. The populated area east of Spokane is presently served by septic tanks and drain fields.

Outside of the Spokane Service Area, the major discharge of municipal wastes is to the South Fork of the Coeur d'Alene River. A waste load of 10,000 PE of raw domestic wastes is discharged to the river from the communities of Wallace, Mullan, Osburn, Silverton, Smelterville, and the Burke-Mace-Gem area. In addition, the City of Kellogg discharges 1,000 PE after treatment in lagoons. High bacterial contamination of this stream has resulted. Planning is underway to provide sewage treatment for the communities in the area. The South Fork of the Coeur d'Alene River Sewer District has completed an engineering study on sewage collection and treatment, and is in the process of securing financing.

Industries

Clark Fork Subbasin Industrial waste sources contribute 27,130 PE, or 23 percent of the subbasin's total waste loading. The majority of the industrial waste facilities in the subbasin consist of lagoons. The overall reduction of industrial wastes is about 90 percent, with 39 percent for the food industry, 92 percent for the pulp and paper industry, and 53 percent for the lumber and wood products industry.

In the Butte-Anaconda Service Area, Silver Bow Creek is used to transport industrial wastes to lagoons near Warm Springs. All of the untreated domestic wastes from Butte and its suburbs, and the acid mine wastes from mining operations in the vicinity

of Butte are transported by Silver Bow Creek to a large lagoon located on the Clark Fork River at River Mile 476. The domestic wastes from industrial areas are transported by local drainage channels to a lagoon near the acid waste lagoon. Both ponds accomplish sedimentation, and the overflow of the alkaline lagoon is directed to the acid lagoon for neutralization, coagulation, and sedimentation. If neutralization is not achieved, lime is added before the effluent is discharged. This neutralization causes the large iron concentrations entering with the acid mine wastes to precipitate. Effective removal of both organic domestic wastes and inorganic mining wastes is accomplished by this system of lagoons.

The Missoula Service Area is a major source of industrial wastes discharged to the Clark Fork River. A mining company's sawmill at Bonner, a few miles above Missoula, contributes 5,000 PE from hydraulic debarker wastes. A 1,250-ton-per-day kraft pulp mill is located 12 miles downstream from Missoula. The mill employs chemical treatment of its black liquors and uses save-alls. In addition to in-plant control, over 700 acres of lagoon storage are used to treat and hold wastes to be released during periods when the flow in the Clark Fork exceeds 10,000 cfs. Release of these wastes is supervised by the Montana State Department of Health, and bioassays are conducted by the industry to determine the quantities of wastes which may be released. Releases range up to 420,000 PE, with 20,000 PE being the annual average discharge. The Montana Water Quality Standards call for solids removal and aeration by June 30, 1970.

The only other major industrial waste sources are composed of the several manganese mines and a manganese concentrating mill in the Philipsburg area. The mill receives water from the pumping of a nearby mine. The mill wastes are settled before being discharged to the City of Philipsburg sewer system. This area also contributes inorganic pollution leached from the tailing piles, especially during periods of heavy rainfall. The magnitude and extent of this pollution are unknown.

Flathead Subbasin Industrial waste problems in the Flathead Subbasin are very limited. Only one industry is not providing satisfactory treatment of wastes. About 300 PE are discharged to Spring Creek without any form of treatment.

Pend Oreille Subbasin In the Newport, Priest River, and Sandpoint area, the principal industrial community consists of numerous sawmills. While the exact nature and quantity of the sawmills' wastes are not known, it appears that most of these mills provide certain good housekeeping measures, such as collection and burning of sawdust, wood chips, and bark. These industries either

are complying with State requirements or have initiated programs to attain compliance with State regulations.

In the Metaline Falls area, the major waste sources are from the mining industry. Most important are the wastes and drainages from several lead and zinc mines, three smelters, and tailing ponds in the area. Inorganic wastes from these operations are presently discharged to the Pend Oreille River and have damaged the stream biota from Metaline Falls to the river's mouth.

Kootenai Subbasin In general, industrial pollution has been a minor problem in this subbasin.

The largest industry in the area is a papermill located in Libby. This firm produces finished lumber, plywood, and wood sugar. The mill provides satisfactory in-plant control measures and facilities for removal of wood solids from lumbering production. Although no information is available as to the nature and amount of wastes resulting from the production of wood sugar, it is known that the process involves sizable quantities of water with the possible discharge of polluting waste water. The mill has a secondary treatment plant for sanitary wastes, which discharges about 50 PE to the Kootenai River.

A mining company mines and refines vermiculite from extensive deposits about 7 miles east of Libby. The company has recently modified the plant for solids removal and recirculation which should end pollution of Rainy Creek.

Spokane Subbasin The degree of industrial waste treatment in the Spokane Subbasin is quite low. Only three percent of the industrial waste production of 222,200 PE receives treatment, since the mining and milling industry along the South Fork of the Coeur d'Alene River and the pulp and papermill at Millwood provide only partial treatment. Most of the industries in the Spokane area are connected to the public sewer system, and their wastes receive primary treatment. Other industries in the Spokane area and lumbering in the Coeur d'Alene area generally provide adequate treatment.

One pulp and papermill in the Spokane Service Area has no conventional treatment, except in-plant control. The company relies on land application of spent sulfite waste liquor in the summer months to reduce waste loadings discharged to the Spokane River. The average organic waste load discharged to the Spokane River is about 210,000 PE. In addition, large quantities of settleable and suspended solids are released. The Washington Water Quality Standards Implementation Plan lists it in need of

complete secondary treatment, with secondary treatment or land disposal of the sulfite waste liquor effluent by September 1971.

Both the South Fork and the main stem of the Coeur d'Alene River have been destroyed for all water uses except waste disposal. The South Fork of the Coeur d'Alene River receives untreated wastes from mine tailings, acid industrial wastes from zinc and lead smelter operations, phosphoric acid wastes, and wastes from an antimony plant on Big Creek. The mine and smelter wastes, containing heavy loads of suspended sediment and biologically toxic concentrations of lead and zinc, have been the prime cause of pollution. The State of Idaho reports that the mining operations are installing tailing ponds to remove silt and sand from mine washings, and are studying treatment procedures for the reduction of contaminants from metal-processing operations and significant sources of mine drainage.

Other industrial waste sources in the subbasin include the aluminum mills at Trentwood and Mead, a slag reclamation plant in Spokane, and a food-processing plant at Post Falls, Idaho. The aluminum mills' wastes are 15 mgd of cooling water and domestic wastes which receive secondary treatment. The Washington Water Pollution Control Commission does not consider the mills to be major sources of pollution. The slag reclamation plants, which contain 30,000 mg/l of chlorides, receive sedimentation before being disposed of to a city sewer which discharges directly to the Spokane River. During periods of low flow, it is estimated that this results in a 1.6 mg/l contribution to the river's chlorides. The State of Washington Water Quality Standards indicate that the company is in need of chemical treatment and outfall improvement. The facilities are to be in operation by September 30, 1971. The food-processing plant at Post Falls, Idaho, discharges 6,000 PE of food-processing wastes to the Spokane River without treatment.

Rural-Domestic

A summary of the population served by individual waste disposal facilities is presented in table 23. About 42 percent, or 246,700 persons, are served by rural systems.

Table 23 - Summary of Population Served by Individual Waste Disposal Facilities, Subregion 1 1/

Subbasin	Population Served Thousands	Percent Subregion Population	Percent Subbasin Population
Clark Fork	47.2	7.8	31.1
Flathead	29.1	4.8	59.0
Pend Oreille	8.3	1.4	42.3
Kootenai	18.6	3.1	77.1
Spokane	143.5	24.1	41.0
Total	246.7	41.2	

1/ Derived as a residual from FWPCA Municipal and Industrial Waste Inventory, Clark Fork-Kootenai-Spokane Subregion, 1965.

The only problem areas presently associated with rural-domestic wastes are in the Spokane Valley, and along Coeur d'Alene, Flathead, and Pend Oreille Lakes. The populated valley east of Spokane contains a population of some 50,000 in unsewered, unincorporated communities and subdivisions which, by disposing of wastes through septic tanks and tile fields, pose a pollutional threat to the area's abundant ground-water supply. Pend Oreille, Coeur d'Alene, and Flathead Lakes receive untreated sanitary wastes from the lakeshore and houseboat resident population, estimated at nearly 2,000 PE. The summer population in these areas is probably several times this number. The States of Idaho, Washington, and Montana are initiating measures to solve these problems.

Irrigation

Approximately 480,000 acres are presently irrigated in the Clark Fork-Kootenai-Spokane Subregion. This requires 1,974,000 acre-feet of water diverted annually, of which about 1,244,000 acre-feet return to streams as irrigation return flows. Sprinkler methods of irrigation are practiced on about 30 percent of the irrigated land, and the remaining land is generally irrigated by ridge and furrow methods.

The major areas of irrigation diversions and return flows are in the Clark Fork, Bitterroot, and Flathead Valleys. No major pollution problems have been reported in these or other areas as a result of irrigation.

Agricultural Animals

Agricultural animals are considered to be a major waste source in the Clark Fork-Kootenai-Spokane Subregion, although the impact of animal wastes on water quality is difficult to determine. The large populations of animals--cattle, sheep, and poultry--produce an estimated waste loading equivalent to that from a population of 3.1 million persons. An estimated 95 percent of the waste loading is removed by soil filtering and natural decomposition, so that about 155,000 PE eventually reach waterways.

Generally, the waste loading attributed to the animal population does not represent a meaningful figure, since the animal population is diffused throughout the subregion. However, feedlots, dairies, and poultry houses can be sources of concentrated waste loadings. Water quality impacts have been noted on several tributary streams such as Hangman Creek in the vicinity of Tekoa, Washington. The effects of wastes from stockyards upon ground water in the City of Spokane area and the influences of livestock concentrations along the banks of the Spokane River downstream from Long Lake are considered to be important. However, their impacts remain to be evaluated and corrected.

Other Land Uses

The production and transport of sediment are the most significant quality impairments resulting from land use in the Clark Fork-Kootenai-Spokane Subregion. The sediment yield ranges between 0.02 and 4.0 acre-feet per square mile per year, and the greatest yields are in the agricultural areas near Spokane, Washington, and above and below Flathead Lake in Montana. Other high yields may result from logging or grazing on some of the steep mountain slopes. The highest yields of 1.5 to 4.0 acre-feet per square mile per year occur only in a very small area in the Latah Creek basin on the Washington-Idaho State line. However, sediment yields are high over most of Spokane County, Washington. Gravel and dirt roads in mountainous areas are also significant contributors of sediments.

Others

Recreation, navigation and dredging, and natural sources are considered to be relatively minor pollution sources in the Clark Fork-Kootenai-Spokane Subregion.

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Present Water Quality

The Washington Water Pollution Control Commission maintains basic data stations in cooperation with the Geological Survey on the Spokane River at Otis Orchards, Washington, and Long Lake; on the Little Spokane River at Dartford, Washington; and on the Pend Oreille River at Newport, Washington; and Waneta, B. C., Canada (formerly at Metaline Falls, Washington). Several agencies have also collected water quality data for short-term surveys. In general, this is the only type of data available for the Idaho and Montana portions of the subregion. A summary of annual mean and extreme values for selected water quality parameters is presented in table 24 where sufficient data are available.

Streams within the subregion are generally fast moving, well-aerated streams with dissolved oxygen levels near saturation. However, during the summer months when streamflows are low and seasonal waste loadings are high, oxygen levels are depressed in three areas. Dissolved oxygen levels often drop below 2 mg/l in Ashley Creek from Kalispell to the mouth. Silver Bow Creek, part of the Clark Fork system running from Butte to Warm Springs, is completely devoid of oxygen as a result of its use as a means of transporting municipal and industrial wastes downstream to oxidation ponds. During the summer, the Spokane River below the Inland Empire Paper Company experiences depressions of several milligrams per liter in dissolved oxygen. This condition extends into Long Lake and becomes worse in conjunction with ponding. The lake experiences periodic algal growths and stratification, both of which add to the dissolved oxygen problem. While oxygen levels near the surface are supersaturated due to photosynthetic activity, concentrations diminish at deeper levels because of lack of reaeration opportunity and a constant drain on the oxygen resource by decaying organics. At levels below 30 feet, the water is often devoid of oxygen. Such conditions affect the Spokane River downstream from Long Lake Dam because water is released from low-level outlets. The result is a low dissolved oxygen concentration for several miles beyond the dam.

Bacterial quality is generally satisfactory for water-contact recreation and other uses. However, limited bacteriological data indicate that high coliform densities exist below many major population centers. Specific areas of concern include the South Fork Coeur d'Alene River, with concentrations up to 24,000 organisms/100 ml; the Spokane River from Millwood, Washington, to Long Lake, with levels up to 240,000 organisms/100 ml; and Ashley Creek below Kalispell, with levels up to 390,000 organisms/100 ml recorded in 1957.

Table 24 - Summary of Water Quality Data Subregion 1 1/

	River Mile	D.O. (mg/l)	T (°C)	Coliform MPN/ 100ml	pH	Color PT-CO Units	Hard. (mg/l)	Turb. (JTU)	TDS (mg/l)	Ortho PO_4 (mg/l)	NO_3-N (mg/l)	Fe (mg/l)
Clark Fork Subbasin												
Clark Fork River at Deer Lodge	745.5-456											
Mean		--	11.1	--	7.4	--	354	--	533	--	1.24	0.49
Min.		--	0.6	--	6.8	--	214	--	312	--	0.00	0.10
Max.		--	17.8	--	8.4	--	440	--	630	--	3.50	2.20
Clark Fork River below Garrison	745.5-443											
Mean		--	11.1	--	8.0	--	279	--	412	--	0.54	0.62
Min.		--	0.0	--	7.6	--	157	--	216	--	0.00	0.10
Max.		--	17.8	--	8.6	--	390	--	516	--	3.50	2.14
Clark Fork River at Ravenna	745-386											
Mean		--	10.0	--	8.0	--	286	--	388	--	0.18	0.71
Min.		--	1.7	--	7.6	--	187	--	236	--	0.00	0.10
Max.		--	17.3	--	8.3	--	358	--	452	--	0.50	2.50
Clark Fork River at East Missoula	745.5-363											
Mean		9.7	10.0	--	8.0	--	179	--	229	--	1.06	0.29
Min.		8.4	1.1	--	7.7	--	105	--	106	--	0.00	0.00
Max.		12.6	16.1	--	8.6	--	231	--	324	--	11.20	1.16
Clark Fork River at Six Mile	745.5-330											
Mean		10.2	8.4	--	7.9	--	135	--	172	--	0.20	0.36
Min.		7.1	0.6	--	7.5	--	71	--	88	--	0.00	0.04
Max.		12.6	18.9	--	8.4	--	182	--	224	--	0.70	1.36
Clark Fork River at Thompson Falls Res.	745.5-208											
Mean		--	--	--	--	--	100	--	109	--	0.20	0.15
Min.		--	--	--	--	--	50	--	70	--	0.00	0.00
Max.		--	--	--	--	--	132	--	150	--	0.90	0.56
Little Blackfoot River at Garrison	745.5-445.7-2.0											
Mean		--	--	--	8.0	--	158	--	195	--	0.15	0.33
Min.		--	--	--	7.6	--	78	--	108	--	0.00	0.00
Max.		--	--	--	8.3	--	385	--	582	--	0.90	2.10
Blackfoot River near Bonner	745.5-364.6-2.0											
Mean		9.5	--	--	8.1	--	125	--	132	--	0.10	0.27
Min.		8.6	1.7	--	7.8	--	83	--	112	--	0.00	0.00
Max.		11.6	15.0	--	8.4	--	165	--	152	--	0.50	1.06
Bitteroot River near Missoula	745.5-350.5-1.0											
Mean		9.8	--	--	7.8	--	90	--	71	--	0.07	0.30
Min.		8.0	3.3	--	7.3	--	31	--	46	--	0.00	0.00
Max.		11.8	14.5	--	8.2	--	110	--	122	--	0.40	1.06
Flathead Subbasin												
Flathead River at Columbia Falls	745.5-245.0-143											
Mean		--	--	--	7.5	--	88	--	101	--	0.27	0.002
Min.		--	--	--	7.1	--	69	--	89	--	0.00	0.00
Max.		--	--	--	8.0	--	107	--	123	--	1.40	0.06
Flathead River at Kerr Dam	745.5-245.0-72											
Mean		--	--	--	--	--	102	--	100	--	0.18	0.20
Min.		--	--	--	--	--	88	--	86	--	0.00	0.00
Max.		--	--	--	--	--	126	--	142	--	0.50	1.16
Pend Oreille Subbasin												
Pend Oreille River at Newport	745.5-88.3											
First Quarter												
Mean		12.5	3.2	101	7.8	3	83	4	99	0.016	0.05	--
Min.		11.1	0.0	0	7.0	0	77	0	91	0.000	0.02	--
Max.		15.0	7.8	930	8.1	10	87	10	105	0.050	0.09	--
Second Quarter												
Mean		11.5	12.0	119	7.8	4	74	6	89	0.033	0.05	--
Min.		9.4	5.1	0	7.3	0	64	0	74	0.000	0.00	--
Max.		13.6	19.8	930	8.1	5	84	15	102	0.360	0.14	--

Table 24 (Continued)

	River Mile	D.O. (mg/l)	T (^oC)	Coliform MPN/ 100ml	pH	Color PT-CO Units	Hard. (mg/l)	Turb. (JTU)	TDS (mg/l)	Ortho PO_4 (mg/l)	NO_3-N mg/l)	Fe (mg/l)
Pend Oreille River at Newport												
Third Quarter												
Mean		8.8	18.3	207	7.9	4	77	2	89	0.027	0.06	--
Min.		8.0	13.5	0	7.1	0	71	0	82	0.000	0.00	--
Max.		9.6	24.0	1,500	8.8	5	84	5	102	0.130	0.27	--
Fourth Quarter												
Mean		10.9	6.3	1,443	7.9	3	81	1	98	0.031	0.05	--
Min.		7.6	0.5	0	7.1	0	73	0	92	0.000	0.00	--
Max.		12.8	11.0	24,000	8.8	5	87	5	106	0.240	0.14	--
Annual												
Mean		10.9	9.9	453	7.8	4	79	3	94	0.027	0.05	--
Min.		7.6	0.0	0	7.0	0	64	0	74	0.000	0.00	--
Max.		15.0	24.0	24,000	8.8	10	87	15	106	0.360	0.27	--
Pend Oreille River at Metaline Falls	745.5-27.0											
First Quarter												
Mean		12.5	2.7	255	7.8	4	80	2	95	0.017	0.04	
Min.		12.0	0.0	0	7.7	0	75	0	87	0.000	0.02	
Max.		13.5	7.5	1,500	8.1	5	84	5	107	0.040	0.09	
Second Quarter												
Mean		11.8	12.2	214	7.8	5	68	5	85	0.024	0.03	
Min.		9.8	6.1	0	7.7	5	61	5	72	0.000	0.00	
Max.		13.7	19.6	930	8.0	5	77	5	96	0.130	0.07	
Third Quarter												
Mean		8.9	19.1	5,897	8.1	4	74	2	85	0.013	0.02	
Min.		7.5	13.5	0	7.3	0	68	0	79	0.000	0.00	
Max.		11.1	24.0	24,000	8.5	5	78	5	94	0.030	0.07	
Fourth Quarter												
Mean		11.5	5.1	1,341	7.9	4	80	2	95	0.016	0.04	
Min.		10.7	0.5	0	7.4	0	76	0	91	0.000	0.00	
Max.		12.8	9.0	7,500	8.2	5	84	5	100	0.040	0.09	
Annual												
Mean		11.0	10.4	2,005	7.9	4	75	2	90	0.017	0.03	
Min.		7.5	0.0	0	7.3	0	61	0	72	0.000	0.00	
Max.		13.7	24.0	24,000	8.5	5	84	5	107	0.130	0.09	
Pend Oreille River at Waneta, B. C.	745.5-0.1											
First Quarter												
Mean		14.8	3.3	59	7.7	3	85	6	100	0.016	0.05	
Min.		13.6	0.5	36	7.6	0	82	5	99	0.010	0.02	
Max.		16.8	6.0	91	7.8	5	88	10	102	0.020	0.07	
Second Quarter												
Mean		11.2	12.8	41	7.8	5	71	16	84	0.023	0.09	
Min.		9.3	8.5	0	7.5	5	67	5	77	0.010	0.05	
Max.		12.8	17.5	91	7.9	5	77	40	93	0.040	0.14	
Third Quarter												
Mean		9.9	19.3	55	7.8	1	76	6	93	0.018	0.04	
Min.		8.6	18.0	0	7.7	0	72	0	87	0.010	0.00	
Max.		11.0	20.8	91	7.8	5	82	15	98	0.030	0.07	
Fourth Quarter												
Mean		12.4	8.3	106	7.9	4	79	4	97	0.017	0.04	
Min.		10.2	4.0	0	7.7	0	76	0	89	0.000	0.02	
Max.		14.1	14.0	230	8.2	5	82	5	102	0.040	0.05	
Annual												
Mean		12.1	10.4	68	7.8	3	78	8	94	0.018	0.05	
Min.		8.6	0.5	0	7.5	0	67	0	77	0.000	0.00	
Max.		16.8	20.8	230	8.2	5	88	40	102	0.040	0.14	

Table 24 (Continued)

	River Mile	D.O. (mg/l)	T (°C)	Coliform MPN/ 100ml	pH	Color PT-CO Units	Hard. (mg/l)	Turb. (JTU)	TDS (mg/l)	Ortho PO_4 (mg/l)	NO_3-N (mg/l)	Fe (mg/l)
Spokane Subbasin												
Spokane River at Otis Orchards	643.0-96.3											
First Quarter												
Mean		12.7	2.9	1,193	7.1	5	22	3	41	0.04	0.05	
Min.		11.0	0.0	0	6.9	0	20	0	35	0.00	0.02	
Max.		14.0	6.8	9,300	7.4	10	24	5	46	0.11	0.11	
Second Quarter												
Mean		10.8	13.4	717	7.1	6	20	3	38	0.04	0.03	
Min.		7.9	5.6	0	6.9	5	18	0	31	0.01	0.00	
Max.		13.3	20.5	4,600	7.3	10	23	5	45	0.08	0.07	
Third Quarter												
Mean		8.6	19.8	1,106	7.0	3	19	0	34	0.04	0.05	
Min.		7.2	13.0	36	6.3	0	16	0	30	0.01	0.00	
Max.		9.4	27.0	9,300	7.3	5	22	0	41	0.08	0.09	
Fourth Quarter												
Mean		10.9	7.7	22,735	7.1	3	21	0	39	0.03	0.05	
Min.		9.2	3.0	91	6.8	0	20	0	35	0.00	0.00	
Max.		13.1	12.0	240,000	7.4	5	22	0	44	0.08	0.14	
Annual												
Mean		10.6	11.3	6,226	7.1	4	20	1	38	0.04	0.04	
Min.		7.2	0.0	0	6.3	0	16	0	30	0.00	0.00	
Max.		14.0	27.0	240,000	7.4	10	24	5	46	0.11	0.14	
Little Spokane R. at Dartford	643.0-56.3-11.4											
First Quarter												
Mean		11.9	3.7	947	7.6	14	78	34	121	0.12	0.46	
Min.		8.6	0.0	0	7.2	5	51	0	92	0.05	0.09	
Max.		13.7	10.0	4,600	8.2	30	109	100	146	0.25	0.95	
Second Quarter												
Mean		9.6	14.9	2,238	7.6	9	71	10	104	0.10	0.21	
Min.		7.8	10.0	0	7.1	0	48	0	89	0.04	0.00	
Max.		11.3	20.5	24,000	8.0	20	96	25	127	0.13	0.38	
Third Quarter												
Mean		9.6	16.2	2,015	7.9	5	110	2	143	0.09	0.32	
Min.		8.6	10.5	36	7.3	5	102	0	126	0.05	0.20	
Max.		10.9	23.0	24,000	8.4	5	121	10	154	0.13	0.61	
Fourth Quarter												
Mean		11.6	5.4	2,998	7.8	8	102	3	137	0.11	0.43	
Min.		9.4	0.5	0	7.2	5	71	0	109	0.07	0.34	
Max.		13.7	11.0	24,000	8.4	20	117	10	154	0.20	0.72	
Annual												
Mean		10.7	10.0	1,998	7.7	9	91	13	127	0.10	0.36	
Min.		7.8	0.0	0	7.1	0	48	0	89	0.04	0.00	
Max.		13.7	23.0	24,000	8.4	30	121	100	154	0.25	0.95	
Spokane River at Long Lake	643.0-33.3											
First Quarter												
Mean		11.7	3.8	907	7.1	9	52	35	79	0.14	0.43	
Min.		9.1	0.5	0	7.0	5	34	5	58	0.08	0.25	
Max.		14.5	6.0	4,600	7.3	15	74	130	106	0.20	0.79	
Second Quarter												
Mean		12.1	12.3	1,285	7.2	6	36	11	56	0.09	0.17	
Min.		8.0	7.5	0	7.0	5	27	0	45	0.05	0.07	
Max.		14.0	17.0	4,600	7.4	15	50	40	69	0.15	0.29	
Third Quarter												
Mean		4.8	17.6	607	7.3	6	88	3	107	0.24	0.55	
Min.		3.5	15.0	0	7.1	5	69	0	87	0.14	0.43	
Max.		7.2	19.6	4,600	7.6	10	104	10	125	0.44	0.63	
Fourth Quarter												
Mean		7.7	8.5	107	7.2	5	75	35	99	0.18	0.49	
Min.		2.9	3.8	0	6.6	0	34	0	63	0.09	0.23	
Max.		13.4	[illegible]	430	7.8	10	101	260	123	0.33	0.66	
Annual												
Mean		9.2	9.9	708	7.2	7	63	22	86	0.16	0.42	
Min.		2.9	0.5	0	6.6	0	27	0	45	0.05	0.07	
Max.		14.5	19.6	4,600	7.8	15	104	260	125	0.44	0.79	

1/ FWPCA STORET, 1968.

Water temperatures are generally in a range suitable for resident fisheries and other related uses. However, the temperatures in the Spokane River and the lower Pend Oreille River quite often exceed the state standard of 65°F. (18°C.) during the late summer months.

Surface water in the Clark Fork-Kootenai-Spokane Subregion is generally of excellent mineral quality, although serious changes in chemical composition occur in several stream reaches. In the Spokane, Kootenai, and Pend Oreille Subbasins, water is soft to moderately hard, and the total dissolved solids seldom exceed 150 mg/l. In the Blackfoot River and in the Clark Fork River above Missoula, maximum dissolved solids concentrations have exceeded 250 mg/l. In most streams, calcium, magnesium, and bicarbonate are the predominant ions; however, high percentages of sulfate are found in the Coeur d'Alene River. The waters of the subregion contain relatively small amounts of silica, usually averaging less than 10 mg/l. Available data show that the Little Spokane River at Dartford, Washington is the only stream with an average silica concentration of more than 10 mg/l.

Mine wastes and tailings have degraded the chemical quality of waters in the Upper Clark Fork, South Fork of the Coeur d'Alene, and Pend Oreille Rivers.

The headwaters of the Clark Fork River from River Mile 496 to 476 have been designated by the Montana State Legislature to convey industrial wastes from Butte and Anaconda to a treatment lagoon on the Clark Fork River near Warm Springs. Acid mining wastes and alkaline wastes from refining and milling operations have resulted in iron concentrations from 20 to 200 mg/l; copper concentrations as high as 11 mg/l; turbidities from 100 to 200 mg/l (as SiO_2); and hardness values of over 350 mg/l. However, immediately below the lagoons the quality of the Clark Fork is improved. During normal operations, the iron concentration is reduced to 1.2 mg/l or less; the copper concentration is reduced to trace quantities; and the turbidity is decreased to 7 to 9 mg/l (as SiO_2). Nearly all other inorganic toxic pollutants are reduced substantially, including lead, zinc, and arsenic. However, a strike by copper workers created some treatment problems during 1967, which resulted in higher levels of iron, zinc, and copper being released from the lagoon. From River Mile 469 to Pend Oreille Lake, the mineral quality of the Clark Fork continues to improve as tributaries of higher quality enter. The hardness and total dissolved solids decrease from about 350 and 500 mg/l, respectively, at Deer Lodge (R.M. 463) to approximately 100 mg/l at Thompson Falls (R.M. 210). Most cations and anions exhibit a similar decreasing trend. An important exception is the iron concentration, which is consistently above the 0.3 mg/l drinking water standard.

Mining and smelting wastes contribute heavy loads of suspended sediment and biologically toxic concentrations of lead, copper, zinc, and arsenic to the South Fork of the Coeur d'Alene River. Biologically toxic concentrations of lead as high as 19 mg/l and concentrations of zinc varying from 14 mg/l in the vicinity of smelters to one mg/l near Coeur d'Alene Lake have been measured. As a result, the South Fork supports no growths of aquatic vegetation or organisms. The main stem of the Coeur d'Alene River also carries toxic concentrations of heavy metals below its confluence with the South Fork. Farmlands along the river must provide dikes, flood gates, and pumps to prevent these toxic wastes from reaching the fields. Studies of the Coeur d'Alene River indicate that, although the concentrations of these metals are high in the upper portions of the river, the majority of these metals combine with other substances forming insoluble salts which settle out before they reach Coeur d'Alene Lake. The large dilution capacity of Coeur d'Alene Lake further serves to confine the situation to the Coeur d'Alene River drainage and prevents its affecting the quality of the lake or Spokane River, which flows from the lake. However, the basic data station on the Spokane River near the Washington-Idaho state line indicates that relatively high zinc concentrations (0.2 to 0.3 mg/l) are still evident even after travel through the lake.

In the Pend Oreille River below Metaline Falls, Washington, deposits from mining wastes and drainages exert a blanketing effect on the stream channel and are a potential source of toxic materials. During an August 1963 study (23), live box tests with rainbow trout fingerlings strongly indicated that there is no toxicity problem in the Pend Oreille River resulting from the mine effluents. However, the effect of the mine tailing wastes on the bottom fauna of the river is significant. Above the zinc and lead mines, the bottom gravel was clean and a large number of organisms were found. Below the mines, and in Waneta Reservoir, there was an almost complete absence of organisms, and the bottom was covered with mine tailings to an unknown depth.

Several small tributaries have also been seriously affected by mining wastes. Warm Springs Creek in the Clark Fork Subbasin exhibits hardness in the range of 500 to 800 mg/l (as $CaCO_3$) and sulfate concentration near 400 mg/l. Turbidity in Flint Creek has been reported to increase from 10 to 30 mg/l (as SiO_2) by passing through the Philipsburg area because of runoff from abandoned mill tailings. A number of small creeks in the Coeur d'Alene drainage, including Beaver Creek, East Fork of Eagle Creek, Canyon Creek, Nine Mile Creek, and Pine Creek are in about the same condition as the South Fork of the Coeur d'Alene River.

The Spokane River is the only major stream in the Clark Fork-Kootenai-Spokane Subregion showing excessive algal growths.

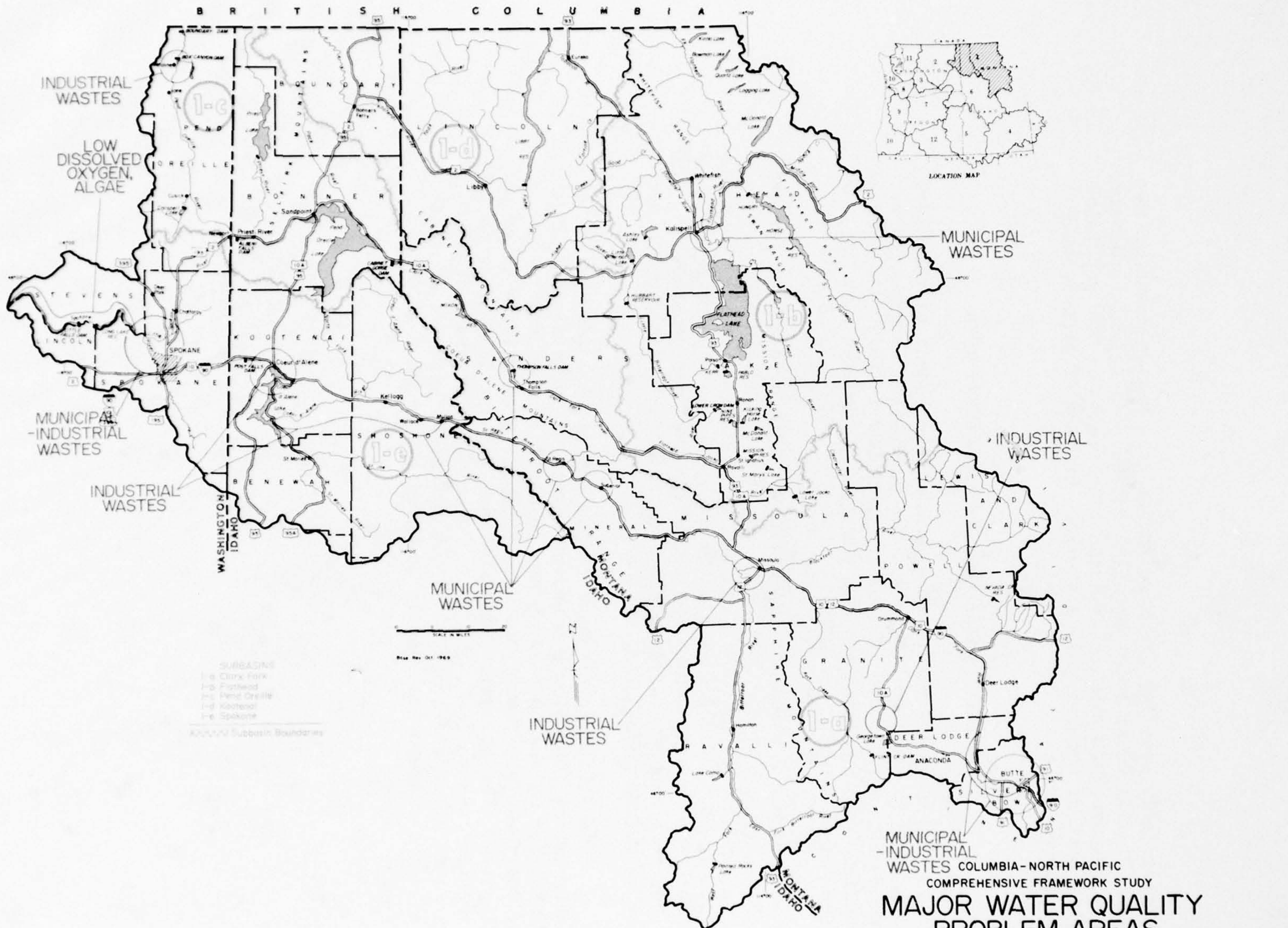
The condition exists from about the Idaho-Washington state line to the mouth of the river and is most evident in Long Lake. Immediately below Post Falls Dam, the Spokane River contains algae and bottom fauna characteristic of a low nutrient stream. The algal forms are chiefly diatoms, the rocks of the bottom are clean, and no filamentous algal forms are found. A very prominent and marked change in the biological ecology occurs in the Spokane River near the state line (about 4 miles below the Post Falls Dam). Heavy sessile growths of algae and bacterial slimes intermixed with blue-green algae become predominant. Although the rapid change is not completely understood, it is thought to result from either underground inflow of high nutrient waters to the river or a decrease in the residual toxicity of heavy metals, particularly zinc, to a level which would allow normal growth of aquatic organisms (13). At Long Lake, below the Spokane Service Area, heavy algal blooms occur in the upper stratified levels. Upon dying, these aquatic growths settle to the bottom and undergo natural decay and decomposition, which exert a heavy biochemical oxygen demand on the already oxygen-deficient waters.

Very little suspended sediment concentration data are available in the Clark Fork-Kootenai-Spokane Subregion. Recently sediment sampling stations have been established by the Geological Survey on the Kootenai and Flathead Rivers. The maximum sediment concentrations recorded at these stations have been 790 and 840 mg/l, respectively. High sediment concentrations have also been observed below major mining operations along the Pend Oreille, South Fork and main stem Coeur d'Alene, and Clark Fork Rivers; and numerous minor streams and creeks.

Summary of Problems

Figure 7 graphically summarizes major water quality problem areas in the Clark Fork-Kootenai-Spokane Subregion. Degradation of water quality is generally associated with wastes from municipalities and industries, although the rural population, agricultural animals, and land-use practices contribute significant quantities of wastes.

Inadequately treated municipal wastes result in bacterial contamination in Ashley Creek below Kalispell, Montana; and the South Fork of the Coeur d'Alene River from Mullan, Idaho, to the mouth. Municipal wastes and pulp and paper wastes, as well as runoff of agricultural waste waters, contribute to low dissolved oxygen levels and excessive algal blooms in Long Lake and the lower Spokane River. Mining and milling wastes have rendered the Clark Fork River between Butte and Warm Springs, Montana (Silver Bow Creek), and the South Fork of the Coeur d'Alene River



COLUMBIA-NORTH PACIFIC
COMPREHENSIVE FRAMEWORK STUDY

MAJOR WATER QUALITY PROBLEM AREAS

CLARK FORK, KOOTENAI, SPOKANE SUBREGION I

1969

FIGURE 7

biologically sterile; and have damaged the bottom fauna of the Pend Oreille River below Metaline Falls, Washington. Drainages and seepage from septic tanks and tile fields in the populated area east of Spokane pose a possible problem of ground-water pollution.

FUTURE WATER QUALITY MANAGEMENT NEEDS

Based on the projected economic development of the Clark Fork-Kootenai-Spokane Subregion, the population is expected to increase from 595,000 in 1965 to 1,140,000 in 2020. This is an increase of 92 percent for the subregion, compared with 121 percent for the region.

Figure 8 shows the projected subbasin populations for the years 1980, 2000, and 2020. The projected subbasin and service area populations for municipal and rural categories are presented in table 24. By 2020, nearly three-fourths of the subregion's population is expected to be located in the Spokane Subbasin. The Clark Fork Subbasin will account for an additional 16 percent of the subregion population.

Industrial development in the future will continue to be based on the subregion's abundant forest and mineral resources. Production by the pulp and paper industry is expected to more than triple; however, lumber and wood products production will decrease slightly. The subregion will continue to be a leading production area for copper, lead, and zinc. Aluminum processing is also expected to expand rapidly. The chemical industry is projected to increase production nearly 20 times by the year 2020.

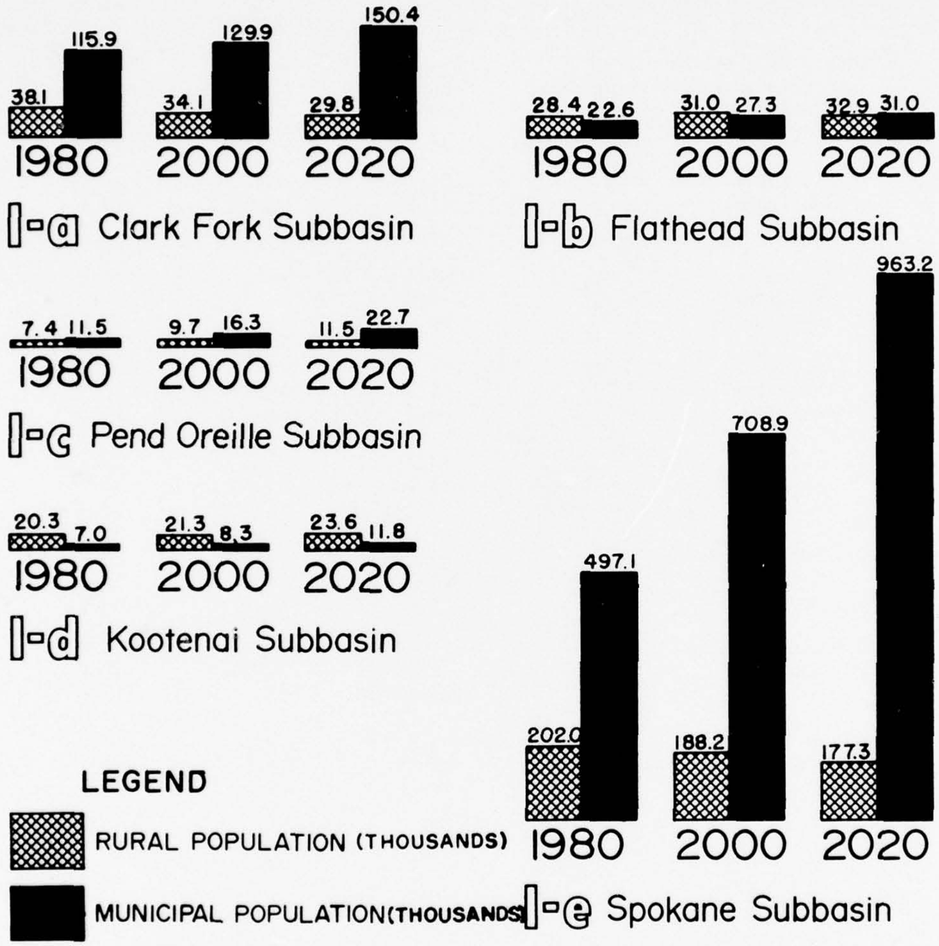


FIGURE 8. Projected Population, Subregion 1

Table 25 - Projected Population, Subregion 1[1/]

Location	1980	2000 (Thousands)	2020
Clark Fork Subbasin	154.0	164.0	180.2
Butte-Anaconda Service Area	60.2	55.6	50.8
Municipal	60.2	55.6	50.8
Rural	--	--	--
Missoula Service Area	51.7	65.2	82.9
Municipal	41.8	59.9	82.9
Rural	9.9	5.3	--
Other	42.1	43.2	46.5
Municipal	13.9	14.4	16.7
Rural	28.2	28.8	29.8
Subtotal	154.0	164.0	180.2
Municipal	115.9	129.9	150.4
Rural	38.1	34.1	29.8
Flathead Subbasin	51.0	58.3	63.9
Municipal	22.6	27.3	31.0
Rural	28.4	31.0	32.9
Pend Oreille Subbasin	18.9	26.0	34.2
Minicipal	11.5	16.3	22.7
Rural	7.4	9.7	11.5
Kootenai Subbasin	27.3	29.6	35.4
Municipal	7.0	8.3	11.8
Rural	20.3	21.3	23.6
Spokane Subbasin	447.9	619.2	826.8
Spokane Service Area	340.5	493.0	661.4
Municipal	290.5	468.0	661.4
Rural	50.0	25.0	--
Other	107.4	126.2	165.4
Municipal	49.6	59.1	85.9
Rural	57.8	67.1	79.5
Subtotal	447.9	619.2	826.8
Municipal	340.1	527.1	747.3
Rural	107.8	92.1	79.5
Total Subregion	699.1	897.1	1,140.5
Municipal	497.1	708.9	963.2
Rural	202.0	188.2	177.3

1/ Differences between totals in this table and source are due to differences in subregion boundaries. The source is based on economic boundaries and this table is based on hydrologic boundaries. The municipal population is defined as that population discharging wastes to a municipal sewerage system. The rural population is defined as the residual.

Future Waste Production

Municipal

The projected municipal raw waste production for the Clark Fork-Kootenai-Spokane Subregion is presented in table 26. The population served by municipal waste collection and treatment systems is expected to increase from 59 percent in 1967 to 84 percent by the year 2020. It has been assumed that the entire populations of the three major service areas will be served by municipal systems at that time.

Table 26 - Present and Projected Municipal Raw Organic Waste Production, Subregion 1 1/

Location	1970	1980	2000	2020 2/
		(1,000's P.E.)		
Clark Fork Subbasin	135.6	144.8	162.4	188.0
Butte-Anaconda Service Area	75.8	75.2	69.5	63.5
Missoula Service Area	42.6	52.2	74.9	103.6
Other	17.2	17.4	18.0	20.9
Flathead Subbasin	26.3	28.2	34.1	38.8
Pend Oreille Subbasin	14.2	14.4	20.4	28.4
Kootenai Subbasin	7.5	8.8	10.4	14.8
Spokane Subbasin	313.5	424.5	658.9	934.2
Spokane Service Area	267.3	362.5	585.0	826.8
Other	46.2	62.0	73.9	107.4
Total Subregion	497.1	620.7	886.2	1,204.2

1/ A factor of 1.25 was applied to the municipal population components to account for the effects of small commercial establishments and other urban activities which add to municipal waste loads.
2/ Interpolated from 1965 data and 1980 projections.

The three major service areas are expected to produce 78 percent of the municipal waste loading in 2020, as compared with 45 percent in 1965. The Spokane Service Area will account for nearly 65 percent of the total service area municipal waste production by 2020.

Industrial

Projected raw organic waste production for the major industrial categories are presented in table 27 for the years 1980, 2000, and 2020. By the end of the projection period, it is expected that industries will contribute approximately 48 percent of the subregion's total organic waste loading. The pulp and paper industry will continue to be the largest organic waste source, contributing approximately 96 percent of the industrial waste production. The primary metals industry will be a major source of inorganic heavy metals, sediments, and sometimes toxic wastes, particularly in the Montana and Idaho portions of the subregion. There is a need for treatment of industrial waste from mining and smelting in the South Fork of the Coeur d'Alene River in the Wallace-Kellogg area of Idaho.

Table 27 - Projected Industrial Raw Waste Production
Subregion 1 1/ (5) (17)

Industrial Category	1970	1980	2000	2020
		(1,000's P.E.)		
Pulp and Paper	564.7	763.0	940.0	1,061.0
Lumber and Wood Products	13.1	13.0	11.9	11.4
Food Processing	12.9	16.2	22.9	32.1
Other	-	-	-	-
Total	590.7	792.2	974.8	1,104.5

1/ Base data from FWPCA inventory of Municipal and Industrial Wastes, Clark Fork-Kootenai-Spokane Subregion 1965.

In general, increases in waste production will occur at existing operations for most industries. However, it seems possible that the pulp and paper, and primary metals industries will develop new sites during expansion. There are several sites in the Montana portion of the subregion which could support a new pulp mill with a capacity of over 1,000 tons/day. The most feasible of these sites appears to be the Plains-Thompson Falls area along the Clark Fork River. Alternate sites considered are in the Columbia Falls area on the Flathead River, and the Libby area near the Kootenai River. The headwater areas of the Blackfoot and Bull Rivers are currently being considered as locations for future primary metals operations.

Several areas along the Kootenai and Clark Fork Rivers have been identified as possible locations for thermal powerplants (1).

Rural-Domestic

The projected rural-domestic waste production is summarized in table 28 for the years 1970, 1980, 2000, and 2020. The rural-domestic waste production was assumed to be equal to the rural population component shown in table 25. For most areas in the subregion the rural waste production is expected to remain relatively constant or to decrease slightly. The Pend Oreille Subbasin shows the only significant increase in rural waste loadings.

Table 28 - Projected Rural-Domestic Raw Waste Production, Subregion 1

Subbasin	1970 1/	1980	2000	2020
		(1,000's P.E.)		
Clark Fork	44.2	38.1	34.1	29.8
Flathead	28.9	28.4	31.0	32.9
Pend Oreille	8.0	7.4	9.7	11.5
Kootenai	19.2	20.3	21.3	23.6
Spokane	131.6	107.8	92.1	79.5
Total	231.9	202.0	188.2	177.3

1/ Interpolated from 1965 data and 1980 projections.

It can be expected that rural developments will become concentrated around lakes. In a number of smaller lakes in the Spokane Subbasin, septic tank drainages have already caused nuisance aquatic blooms, and will result in more serious problems in the future. In the large lakes, such as Coeur d'Alene, Pend Oreille, Priest, and Flathead, rural wastes could result in localized algal problems and bacterial contamination.

Irrigation

In 1966, there were approximately 480,000 acres of land irrigated, which required an annual diversion rate of 4 acre-feet per acre. Irrigated acreage is projected to increase to 860,000 acres by 1980, 950,000 acres by 2000, and 1,320,000 acres by 2020.[1/] However, the diversion rate is expected to decrease to approximately 3 acre-feet per acre. The actual diversion of water for irrigation will, therefore, increase by about 2.1 times by the year 2020. More efficient use and application of water will result in this decrease in division rate per acre, and will generally minimize irrigation as a pollution source. However, all large irrigation developments for a particular river basin will still need to be studied individually to evaluate impacts on water quality.

1/ All data include irrigated cropland plus an allowance for irrigated noncropland.

Other Land Uses

Projections of land use in the subregion, by major types of land use, are shown in table 29. The projections show a decrease in land area for forest and woodland of approximately three percent by the year 2020. In contrast, the wood consumption demand by the forest products industry is expected to increase by 1.25 times during the same period. The potential for erosion and stream damage will be greater as more intensive harvesting methods are employed by forest users. More diversified and intensive land use in several river valleys--particularly the Spokane, Flathead, Clark Fork, and Bitterroot--could possibly result in increased sediment loads for adjacent streams.

Table 29 - Present and Projected Land Use, Subregion 1 (5) (8)

Land Use	1966	1980	2000	2020
		(thousands of acres)		
Cropland	1,552	1,737	1,739	1,930
Irrigated	(465)	(833)	(925)	(1,280)
Nonirrigated	(1,087)	(904)	(814)	(650)
Forest	18,242	18,118	17,974	17,784
Range 1/	1,698	1,439	1,411	1,237
Other 2/	1,327	1,414	1,530	1,644
Total	22,819	22,708	22,654	22,595

1/ Does not include forest range.
2/ Includes barren land, roads and railroads, small water areas, urban and industrial areas, farmsteads, airports, etc.

Increased use of fertilizers on crop and pasturelands in the area surrounding numerous subregion lakes will represent a potential source of nutrients, which could cause serious eutrophication problems. Pesticides and herbicides applied to these lands could also drain into the lakes and build up to toxic levels through the food chain. Lakes in the Spokane Subbasin will be the most seriously threatened by these pollution sources.

Agricultural Animals

The raw organic waste production by the livestock population in the subregion is expected to be equivalent to that from a population of 4,200,000 in 1980; 5,500,000 in 2000; and 7,300,000 in 2020. This would account for approximately 75 percent of the total raw organic waste production for the subregion. In addition, the percentage of the cattle population now on feedlots is expected to increase over present levels.

Recreation

The projected raw waste production by recreation activities in the subregion is summarized as follows:

	Population Equivalents 1/
1970	119,500
1980	162,000
2000	298,000
2020	549,000

1/ Bureau of Outdoor Recreation and U.S.D.A. Forest Service Projections for total man recreation days (TMRD).

In the determination of wastes from recreation activities, the population equivalent is based on the total annual recreation days. The values represent the daily raw waste production for a typical summer weekend. In a number of lakes--particularly Coeur d'Alene, Flathead, Priest, and Pend Oreille Lakes--wastes associated with recreational activities may be the largest source of organic materials, nutrients, and bacteria.

Other Factors Influencing Quality

While power production is not considered as a depletion of the water resource, the structures and management of flows often affect water quality. The impoundment of a free-flowing stream creates a pool in which the physical and chemical properties and the biological populations are modified. Selective withdrawals from different levels result in various dissolved oxygen concentrations and downstream water temperatures.

Nutrients entering the water from municipal sewage, from a Canadian fertilizer plant, and from other sources stimulate aquatic growths. Since many of the streams are nutrient-deficient the result can be beneficial; however, an imbalance of nitrogen and phosphorus can produce excessive growths that cause a nuisance, obnoxious tastes, and other problems. An increase in water temperature resulting from impoundments, depleted flows and heated influents will further compound the problems.

Streamflow management can also have an impact on water quality. When streamflows diminish, water quality suffers drastically. Management programs reflect the public attitude. Achievement of good water management and the flows needed can be realized only with the support of the people, fully informed and aware of the problems and their solutions.

Quality Goals

Quality objectives are based on interstate and intrastate water quality standards established for waters of the subregion. Most of the standards contain an antidegradation provision which ensures that waters whose existing quality is better than the established standards will be maintained at that existing high quality.

The waters in the Montana portion of Subregion 1 are for the most part classified as B-D 1. The water uses are water supply for domestic use--suitable for use after simple disinfection and removal of naturally present impurities, and for the growth and propagation of salmonid fishes and associated aquatic life, waterfowl, and furbearers. According to the water quality standards in Montana for water classified B-D 1, the dissolved oxygen concentration cannot be less than 7 mg/l, temperature should not exceed 67°F. (19.4°C.) turbidity should not increase 5 JTU over natural conditions and organisms of the coliform group should average less than 50 per 100 ml. It should be noted that a section of the Clark Fork River above Warm Springs is classified for "industrial waste use" with correspondingly lower standards.

Waters in the Idaho portion for the most part are protected for domestic and industrial water supply, irrigation, livestock watering, propagation of salmonid fishes, and recreation. The criteria established to protect these uses will not allow waste discharges that will cause the dissolved oxygen to be less than 75 percent saturation at seasonal low, or less than 100 percent in spawning areas during spawning, hatching, and fry stages of salmonid fishes; the temperature to exceed 68°F. (20°C.) objectionable turbidity; and the average coliform concentrations to exceed 240 per 100 ml along the shores of lakes and 50 per 100 ml in the main body of a lake or stream.

The waters of Subregion 1 in the State of Washington are primarily classified as "A." The uses in the Class A category are domestic, industrial, and agricultural water supply; fish propagation and wildlife habitat; general recreation and aesthetic enjoyment; and commerce and navigation. The criteria to protect these waters require the dissolved oxygen concentration to remain above 8 mg/l, temperature not to exceed 68°F. (20°C.), total coliform organisms not to exceed median values of 240 per 100 ml, and turbidity not to exceed 5 JTU over natural conditions.

The above uses and criteria are not inclusive, and the water quality standards should be consulted for specific information on a particular stream. A copy of the complete set of each State's water quality standards is available upon request from

the following State agencies: Washington State Department of Ecology, the Idaho State Board of Health, and the Montana State Water Pollution Control Council.

MEANS TO SATISFY DEMANDS

Controlling pollution in the Clark Fork-Kootenai-Spokane Subregion in order to provide water quality sufficient to adequately serve the river systems' functions will require a coordinated program of waste reduction, flow regulation, application of waste-controlling techniques, and development of a system of cooperative management of the watershed for pollution control.

Waste Treatment

Future Waste Discharges

Based on the treatment levels described in the Regional Summary and on the raw waste projections presented earlier, the projected municipal waste loadings to be discharged to waters of each subbasin are shown in table 30. The industrial waste loadings for major industrial categories are presented in table 31. The total municipal and industrial organic waste loading is expected to be 227,400 PE in 1980; 195,100 PE in 2000; and 238,600 PE in 2020.

By 2020, approximately 64 percent of the municipal waste load reaching waterways is expected to be from the Spokane Service Area. The Missoula and Butte-Anaconda Service Areas will account for an additional nine and five percent, respectively, of the municipal discharge. The remaining waste load will be scattered among the numerous small communities in the subregion.

The most damaging waste loads discharged to streams of the subregion will continue to be mining wastes in the Butte-Anaconda, Metaline Falls, and Coeur d'Alene areas. The water quality standards implementation plan calls for treatment of wastes from the Metaline Falls and Coeur d'Alene areas. However, in the Butte-Anaconda area, the primary metals operations will still discharge partially untreated wastes to Silver Bow Creek, which is classified by Montana State Law as an industrial waterway.

The pulp and paper industry is expected to be the largest industrial discharger of organic waste materials. It has been assumed that any new pulp mills in the subregion will employ chemical recovery facilities and secondary treatment.

Table 30 - Projected Municipal Organic Waste Discharges, Subregion 1

	1980 1/	2000 2/	2020 2/
		(1,000's P.E.)	
Clark Fork Subbasin	21.7	16.2	18.8
Butte-Anaconda Service Area	11.3	6.9	6.3
Missoula Service Area	7.8	7.5	10.4
Other	2.6	1.8	2.1
Flathead Subbasin	4.2	3.4	3.9
Pend Oreille Subbasin	2.2	2.0	2.8
Kootenai Subbasin	1.3	1.0	1.5
Spokane Subbasin	63.7	65.9	93.4
Spokane Service Area	54.4	58.5	82.7
Other	9.3	7.4	10.7
Total Subregion	93.1	88.5	120.4

1/ 85 percent removal of municipal organic waste production.
2/ 90 percent removal of municipal organic waste production.

Table 31 - Projected Industrial Organic Waste Discharges, Subregion 1

Industrial Category	1980 1/	2000 2/	2020 2/
		(1,000's P.E.)	
Pulp and Paper	114.4	94.0	106.1
Lumber and Wood Products	2.0	1.2	1.2
Food Processing	2.4	2.3	3.2
Other	-	-	-
Total Subregion	118.8	97.5	110.5

1/ 85% removal of industrial organic waste production.
2/ 90% removal of industrial organic waste production.

Treatment Costs

Curves showing estimated costs of constructing (total capital) and operating (annual operation and maintenance) municipal sewage treatment plants for various treatment levels are presented in the "Means to Satisfy Demands" section of the "Regional Summary."

Other Pollution Control Practices

Some of the water quality problems of the Clark Fork-Kootenai-Spokane Subregion are beyond the reach of conventional waste treatment and flow regulation. Remedies for these pollutants are not as clear-cut but are just as important in maintaining water quality.

Rural wastes will be of major significance in a number of areas. The disposal of rural wastes to septic tanks and drain fields will continue to represent a possible hazard to the ground-water aquifer of the Spokane area, as well as a number of other more localized areas throughout the subregion. In the lake areas, particularly the Spokane area, and Coeur d'Alene, Priest, Pend Oreille, and Flathead Lakes, it may become necessary to intercept wastes from summer home developments and collect sewage from houseboats for disposal to an approved central sewage treatment facility.

Practices to minimize land runoff of sediments, nutrients, and commercial toxicants are essential for maintenance of water quality in the Clark Fork-Kootenai-Spokane Subregion. Land management practices by agricultural interests in the Bitterroot, Clark Fork, Flathead, and Spokane Valleys must reflect the need for protection against soil erosion. Soil stabilizing practices presently promoted for agriculture should be extended to include logging practices, construction, channel improvements, and other practices that bear upon deposition of soil in water bodies. Logging operations and road construction will likely be the largest sources of damaging localized sediments if proper management practices are not instituted. However, new logging techniques will reduce erosion, so more intensive operations in the future are likely to leave less sedimentation. Watershed management is more important than ever before. Control of fertilizers and commercial toxicants through development of optimal application practices and careful controls is essential, in view of the increasing intensity of use of these materials.

Mining and milling are perhaps the largest controllable cause of sediments. Mining is prevalent in Idaho and Montana, and water quality in numerous streams suffers from severe turbidity from mining operations. The most obvious and serious of these

is the South Fork of the Coeur d'Alene River. Other mining operations, including gravel removing and washing, create localized problems of turbidity and sedimentation. Another problem associated with mining is the concentration of heavy metals in mine washings, and these are extremely toxic to all forms of life. Seepage from old ponds and tailings is a continuous problem and will remain for years after a mine has been closed.

The large animal population in the subregion represents a potential source of organic wastes larger than all other waste sources combined. Fences and simple retaining structures between the animal habitat and watercourses should be provided in order to prevent bank erosion and to limit direct surface drainage so that wastes may decompose through soil processes. At some places it may be preferable to collect the waste from cattle-holding facilities for treatment or distribution to the land as a fertilizer.

Recreation areas will be increasing in numbers, size, and intensity throughout the subregion. Sewage disposal systems adequate to cope with weekend loads from use by thousands will be needed in many recreation areas. Facilities for collection and pickup of litter and garbage must also be made available, since these may add to the waterborne debris load. Restrictions on motorboats on heavily used lakes may be necessary to keep oil and gas pollution at a minimum.

Future power demands and means of satisfying these demands are shown in the Power Appendix. These demands indicate the possibility that thermal powerplants may be constructed in the northwestern Montana area (1). An example site was chosen on the Clark Fork River, which is also representative of other locations on the Clark Fork and Kootenai Rivers. Excess heat will not be discharged to these rivers.

Thermal powerplants will be required to cool waste water before discharge into surface streams, and once-through cooling will be no longer permitted. Other problems at thermal powerplants stem from salt concentrations and corrosion inhibitors present in blowdown wastes. These can be controlled through use of deionized water.

Minimum Flow Requirements

Since waste treatment does not provide an economic solution for complete removal of contaminants from waste waters and waste discharges from non-point sources, a certain amount of streamflow is necessary for dilution and assimilation of residual

wastes. The minimum flow requirement for assimilation of wastes is related to a number of factors, including the strength and deoxygenation capacity of the wastes; and the temperature, reaeration capacity, elevation, and minimum allowable D.O. for the stream.

A set of generalized curves showing minimum flow requirements for raw waste loadings subjected to various treatment levels is presented in figures 9 and 10 for several D.O. objectives, elevations, and self-purification factors (a combined characteristic of the waste and stream). Figure 11 shows generalized areas to which particular graphs are applicable. These figures give only approximate requirements for small to middle-sized communities with a normal mix of municipal and industrial wastes.

From a brief examination of the above-mentioned graphs, it was found that Ashley Creek at Kalispell, Montana, is the only area in the subregion in which existing streamflows do not seem to be sufficient to assimilate projected wastes after treatment.

Streamflow requirements for waste assimilation below the Spokane, Missoula, and Butte-Anaconda service areas have also been developed. The dissolved oxygen objectives and characteristics of the stream receiving wastes are included in each of the graphs for the service areas.

Butte-Anaconda Service Area

The population of the Butte-Anaconda Service Area is projected to decrease steadily from 61,700 in 1965 to approximately 51,000 in 2020. The major industrial waste material will continue to be inorganic sediments and heavy metals such as zinc and copper from primary metals operations.

Figure 12 shows the minimum streamflow requirements for 1980, 2000, and 2020 for assimilation of organic wastes. However, if present treatment practices by the primary metals industry do not change dramatically, this flow will be meaningless, since the heavy metal wastes will render the streams sterile of any aquatic biota.

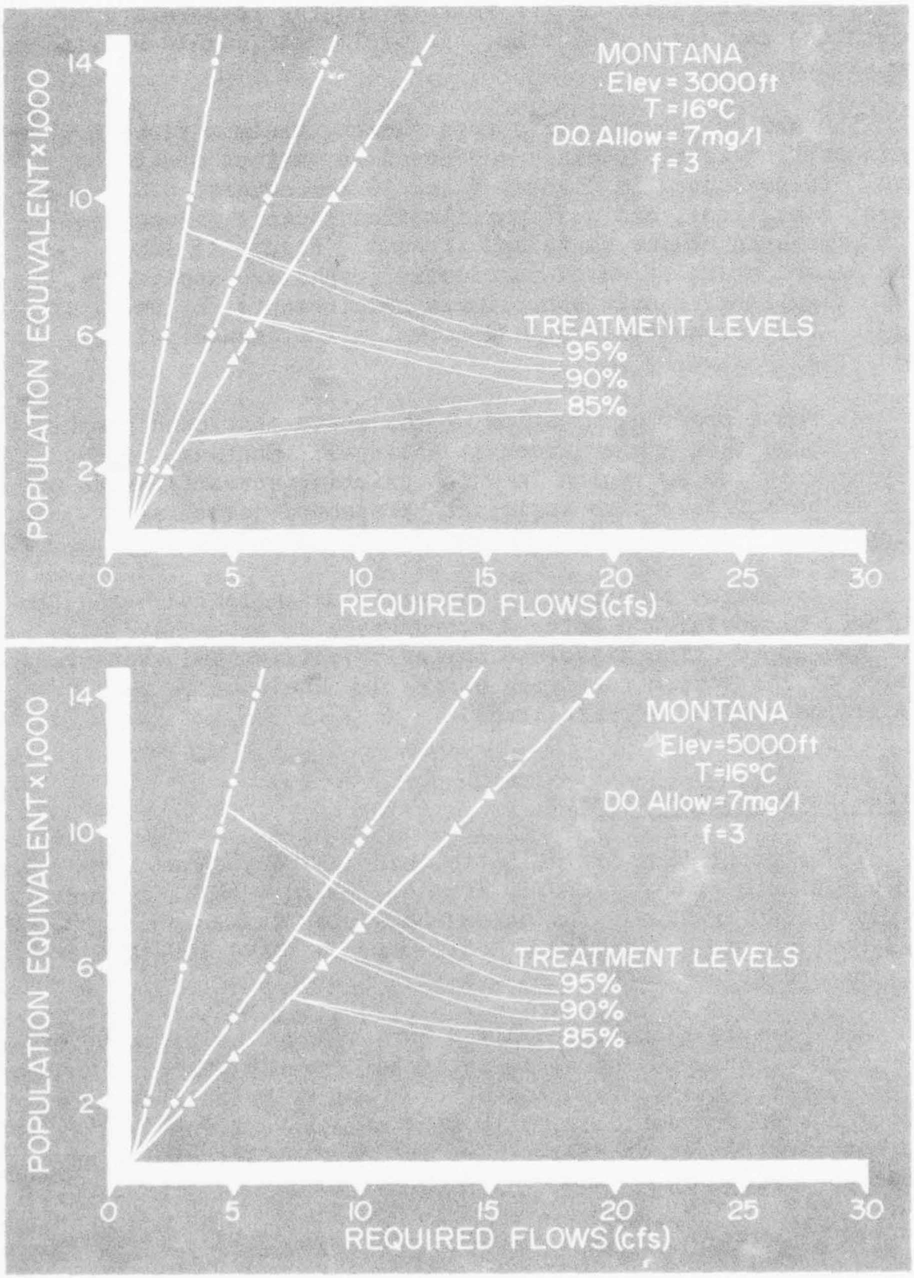


FIGURE 9. Minimum Flow Needs to Maintain Montana Dissolved Oxygen Standards Criteria

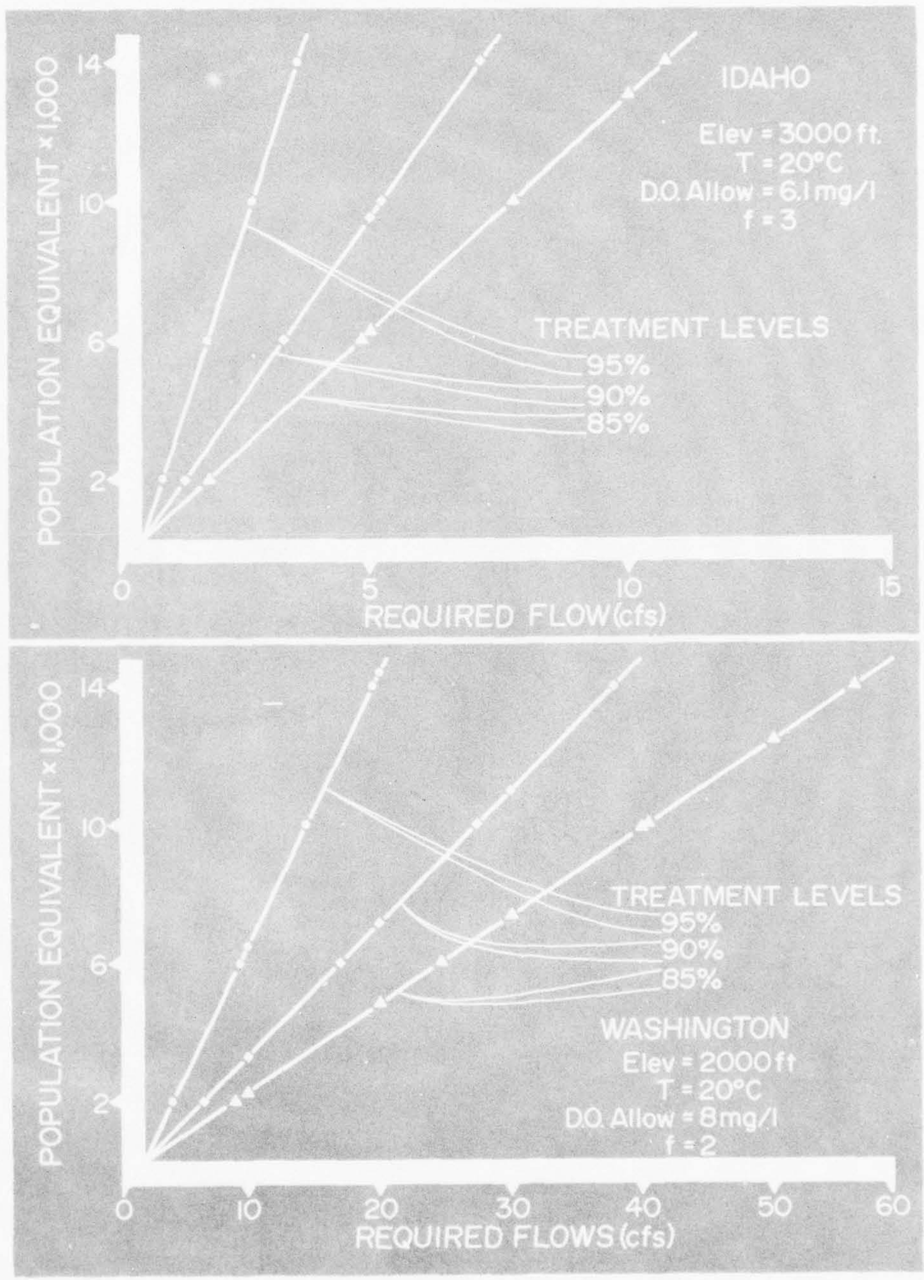
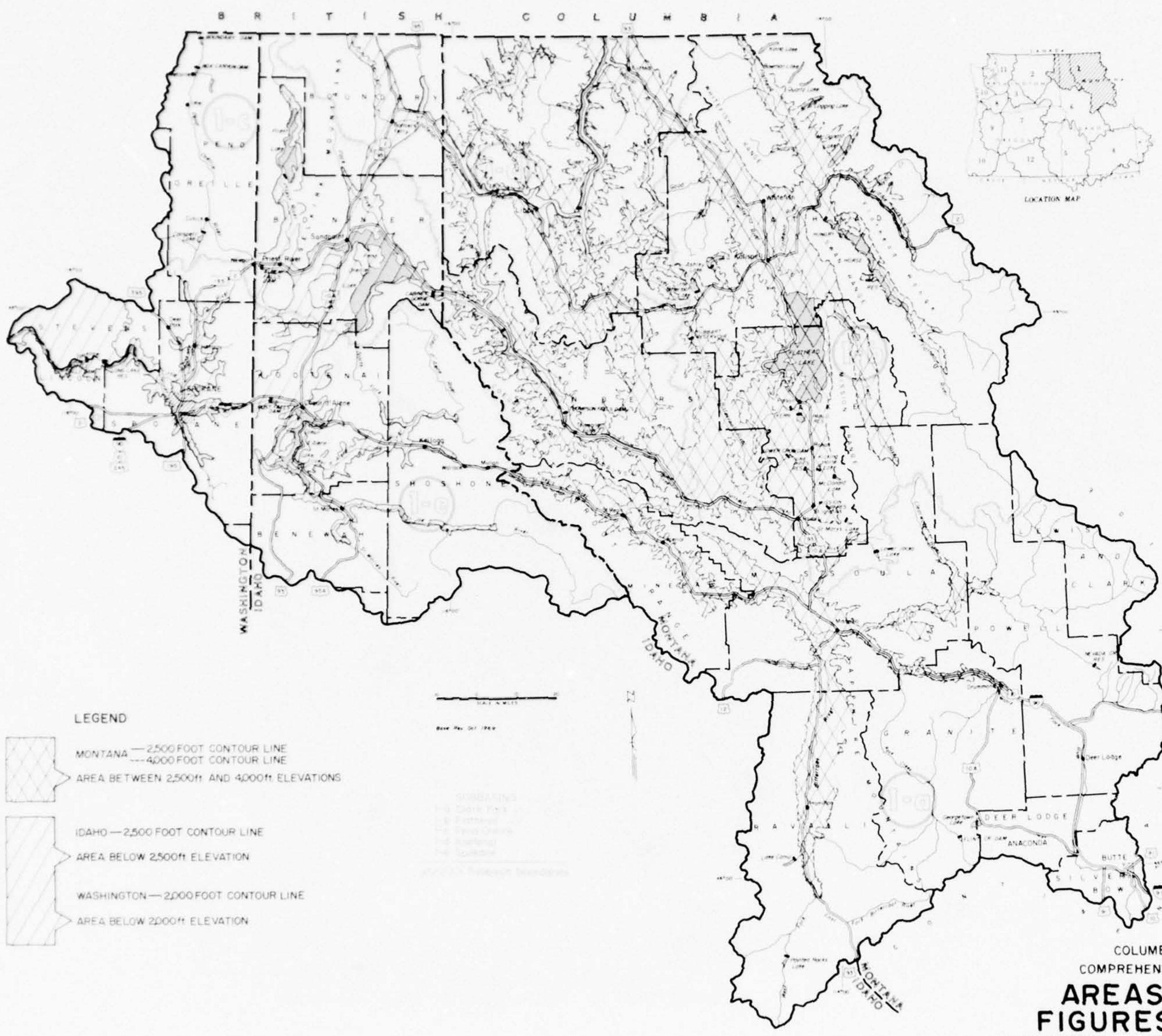


FIGURE 10. Minimum Flow Needs to Maintain Idaho and Washington Dissolved Oxygen Standards Criteria



COLUMBIA-NORTH PACIFIC
COMPREHENSIVE FRAMEWORK STUDY

AREAS TO WHICH FIGURES 9 & 10 APPLY

CLARK FORK, KOOTENAI, SPOKANE SUBREGION I

1969

FIGURE 11

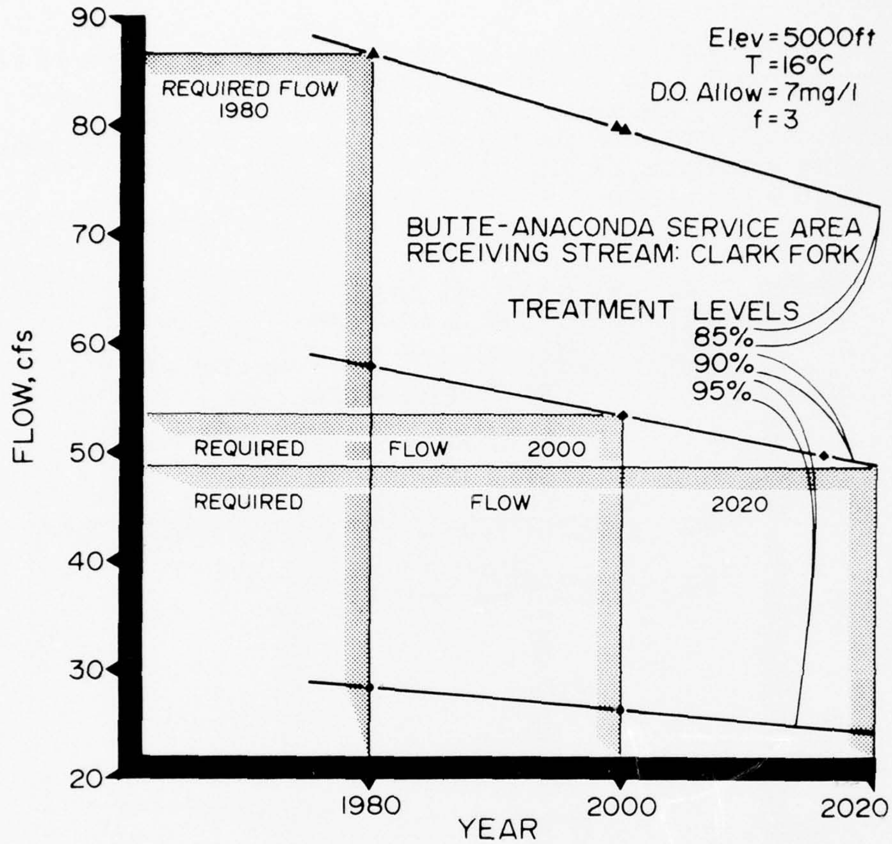


FIGURE 12. Minimum Flow Needs for Water Quality Control--Butte-Anaconda Service Area

Missoula Service Area

The population of the Missoula Service Area is expected to increase from 46,600 in 1965 to 82,900 in 2020. The pulp and paper industry will represent the major waste source, with an estimated raw waste production of 318,000 PE in 1980 through 2020.

Figure 13 presents the minimum streamflow requirements for the projection period. The minimum required flow of 315 cfs in 1980 is well below the one-in-ten-year mean monthly low flow of 710 cfs; therefore, no water quality problems are anticipated.

Spokane Service Area

The population of the Spokane Service Area is expected to decrease from 353,400 in 1965 to 340,000 in 1980; increase to 493,000 in 2000, and to 661,400 in 2020. The pulp and paper industry will represent the major waste source, with an estimated raw waste production of 245,000 PE in 1980; 277,000 PE in 2000; and 368,000 PE in 2020.

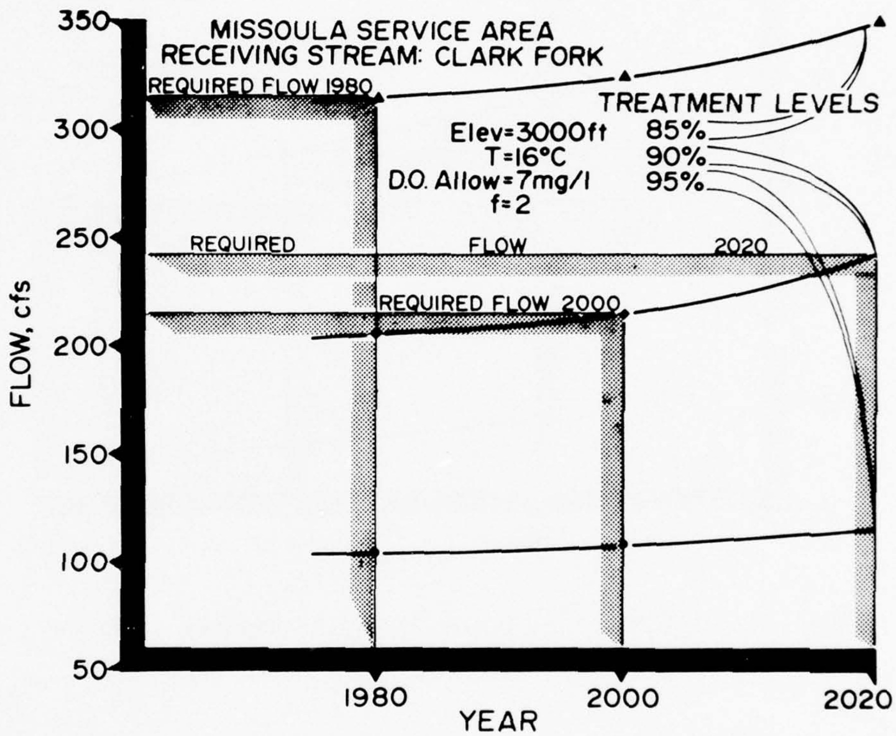


FIGURE 13. Minimum Flow Needs for Water Quality Control--Clark Fork River at Missoula

Figure 14 presents the minimum streamflow requirements for given levels of treatment of the combined municipal and pulp mill wastes for the projection period. The duration curves presented in the Water Resources Appendix indicate that the required streamflow in 2020 of 2,950 cfs at the 90 percent level of treatment will not be met for approximately 44 percent of the time, and at the 95 percent level of treatment the minimum flow of 1,500 cfs will be deficient about 5 percent of the time. Because of the

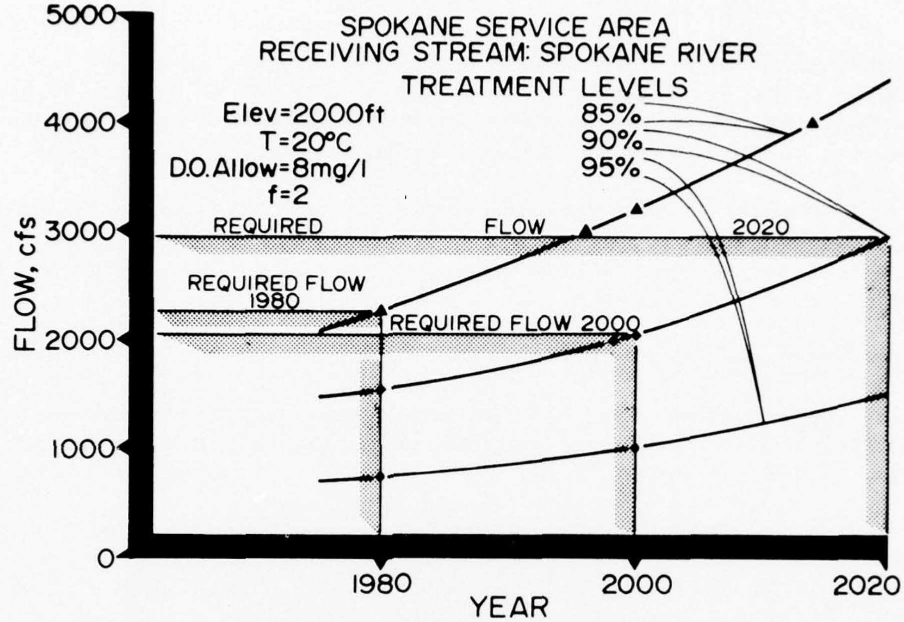


FIGURE 14. Minimum Flow Needs for Water Quality Control--
Spokane River at Spokane

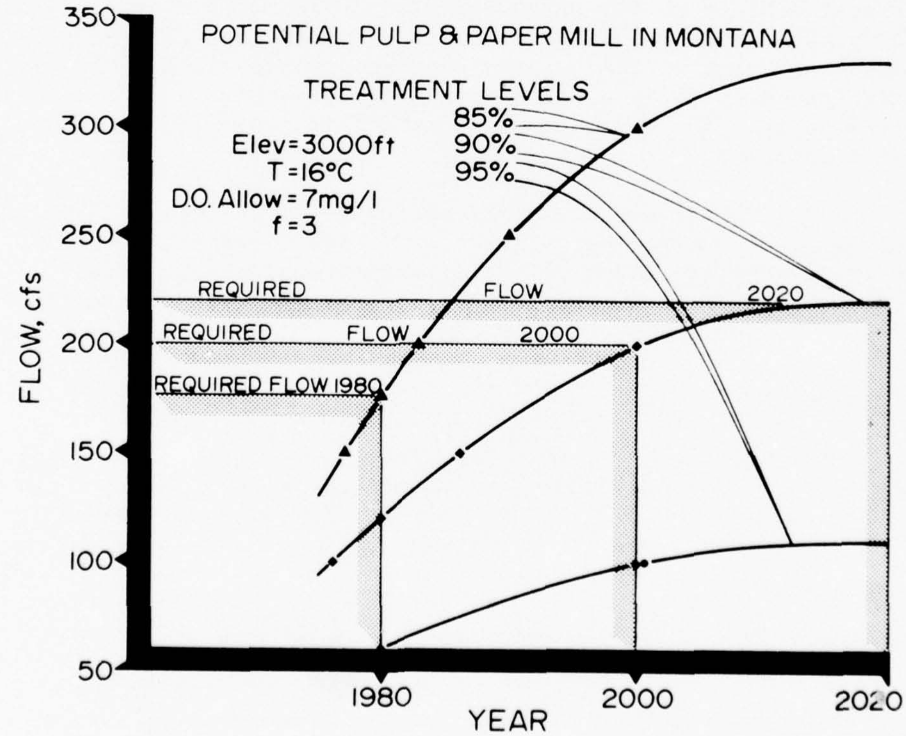


FIGURE 15. Minimum Flow Needs for Water Quality Control--
Potential Pulp and Paper Mill

historical deficient streamflows, low D.O.'s, and the algal blooms in Long Lake, it is apparent that higher degrees of treatment are necessary to remove the maximum amount of organics and nutrients from the waste streams before discharge into the Spokane River.

Temperature and dissolved oxygen concentrations below Long Lake can be controlled with multi-level releases and are not dependent entirely on streamflows.

Other Minimum Flow Requirements

Expansion of the pulp and paper and the primary metals industries will produce a need for additional minimum flow requirements in the subregion.

There are several sites in Montana that could support a new pulp mill. The most likely sites appear to be in the Plains area along the Clark Fork River, the Columbia Falls area on the Flathead River, and the Libby area near the Kootenai River. The raw waste production with chemical recovery is expected to be 200,000 PE in 1980; 345,000 PE in 2000; and 375,000 PE in 2020. Figure 15 shows the minimum streamflow requirements for 1980, 2000, and 2020 for assimilation of the organic wastes. The three rivers all have the needed minimum flows. It should be noted that the curves presented are based on the oxygen requirements only, and the waste water from pulp mills contains many materials that are toxic to the stream biota. The waste can also result in aesthetically objectionable conditions.

Exploration work is being conducted on the mineral deposits located in the upper reaches of the Blackfoot and Bull Rivers. The primary metals industry is currently considering sites for future plants in these locations. The nature of the waste discharges has not yet been determined.

Management Practices

The capacity to control the water resources of the Clark Fork-Kootenai-Spokane Subregion is another important factor in preserving water quality of streams. While flows are generally adequate to assimilate waste discharged to the stream, both now and in the future, a dependable flow must be guaranteed. A number of major dams are being planned, including Libby Dam, which is presently under construction. These could have a significant effect on the flow regimen of major streams by providing storage necessary to meet minimum flows. Water quality must necessarily be considered in the operation of new reservoirs or in changes made in present operating procedures.

LOCATION MAP

SUBREGION 2

SUBREGION 2

UPPER COLUMBIA

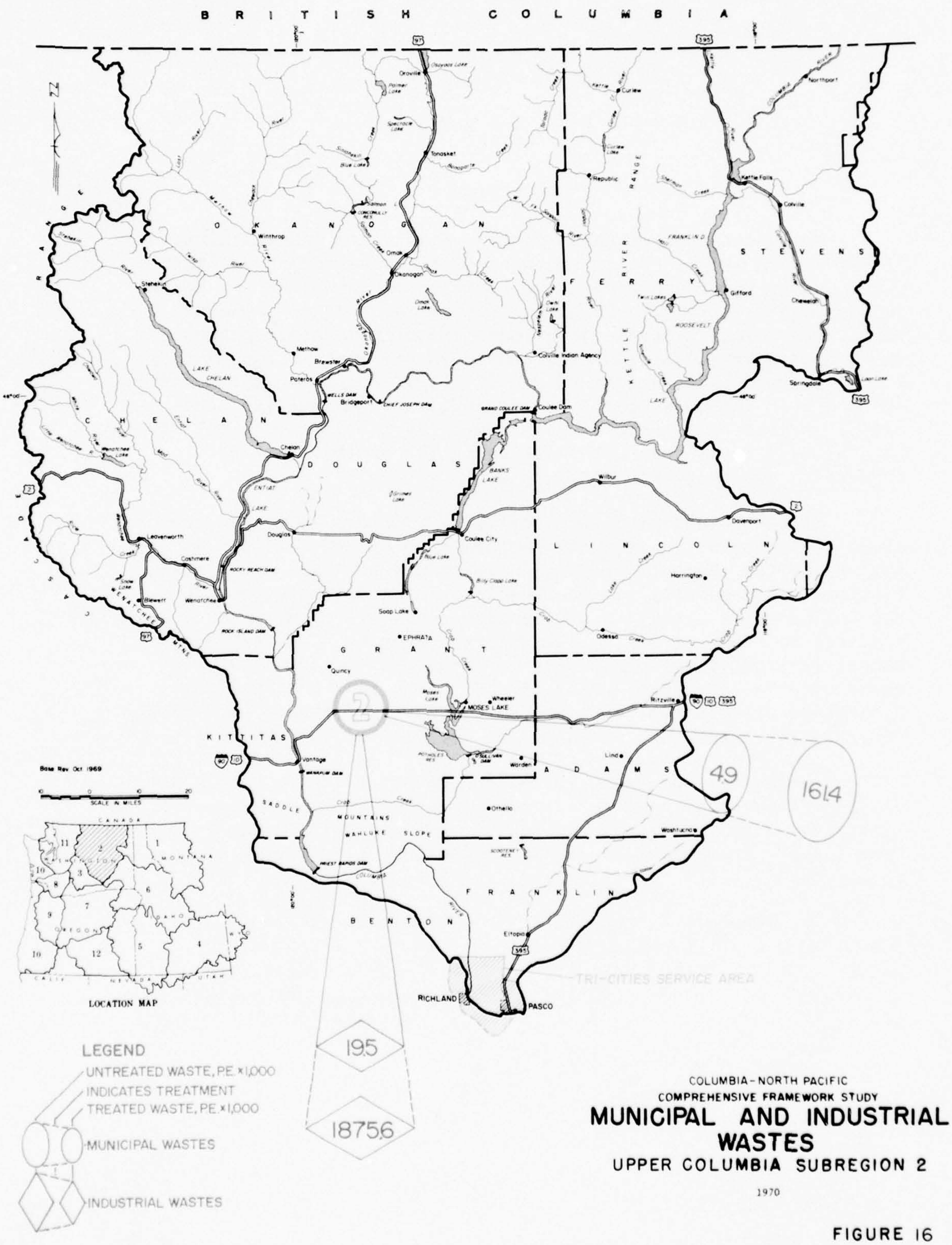
INTRODUCTION

Subregion 2 is in north-central Washington and contains 22,451 square miles. It is composed of the areas draining into the Columbia River above Pasco, except those drained by the Yakima and Spokane Rivers. The Canadian line is the northern boundary, positioned across several north-south trending mountain ranges which make up the Okanogan Highlands. To the west is the Cascade Range, rising to elevations of nearly 10,000 feet. In the central and southern portions of the subregion are the Channelled Scablands, an area of scoured canyons caused by a sudden outbreak of glacial melt-water during the ice age. The southeast corner borders on the Palouse Hills.

Climatic conditions are variable. Summers in the southern areas are relatively hot, with temperatures of 90° to 100°F. (32° to 38°C.) common. The highlands of the northern and western sections are generally somewhat cooler. Winters, sometimes under the influence of extensive arctic airmasses, are cold, with readings to -40°F. (-40°C.) having been recorded. In the Cascade Range, precipitation totals over 80 inches, with annual snow cover of over 100 inches being common. Both snow and total precipitation decrease eastward and southward, to a low of less than 10 inches of annual precipitation in the Channelled Scablands.

The major employment is related to agriculture. There are a limited number of canning, freezing, and dairy processing plants; an aluminum plant; and several primary metals and mining operations. Recreation is an important economic activity that will probably become increasingly significant.

The subregional population in 1965 was about 250,200 persons. Four major urban areas contain about 27 percent of the people. In addition, small towns and villages are scattered throughout the southern sections. Communities are not as numerous in the north.



COLUMBIA-NORTH PACIFIC
COMPREHENSIVE FRAMEWORK STUDY

MUNICIPAL AND INDUSTRIAL WASTES

UPPER COLUMBIA SUBREGION 2

1970

FIGURE 16

PRESENT STATUS

Municipalities and industries are the largest sources of organic wastes in the Upper Columbia Subregion. A graphical summary of the municipal and industrial waste production and discharge is presented in figure 16. The food-processing industry is responsible for most of the industrial waste production. The Hanford Atomic Works is an important source of radiological and thermal wastes. Irrigation practices in the Columbia Basin Project (CBP) area have an important effect on water quality of small streams and ground water.

The quality of the waters of the Upper Columbia Subregion is generally adequate for all uses. However, localized problems do occur. These include high summertime temperatures in the Columbia River and several tributaries; ground-water contamination in certain areas of the Columbia Basin Project; lake and stream enrichment problems, which include Moses Lake; and total coliform organisms in excess of criteria in localized areas including the Lower Okanogan, Colville, and Entiat Rivers.

Stream Characteristics

The principal tributaries of the Columbia River in the Upper Columbia Subregion are the Kettle, Similkameen, Okanogan, Methow, Colville, Chelan, Sanpoil, Nespelem, and Wenatchee Rivers and Crab Creek. The Spokane River is also a major tributary, but is considered in the discussion of Subregion 1. The Similkameen, Methow, Chelan, and Wenatchee Rivers drain from the Cascade Range. The Kettle and Okanogan Rivers originate within Canada. The Colville River originates in the Selkirk Mountains, and the Sanpoil and Nespelem Rivers originate in the interior mountains of northern Washington. Crab Creek provides the major surface drainage from the Columbia Plateau area.

Discharge of the Columbia River far exceeds that of any other stream in the subregion. Although its regimen is affected somewhat by the subregional runoff pattern, flows are principally derived from drainage in Canada and the Clark Fork-Kootenai-Spokane Subregion. The average annual inflow to the subregion from the Columbia River at the International Boundary is 95,800 cfs as compared with the average outflow of 114,100 cfs at Priest Rapids Dam, which is located below most major tributaries.

Surface-Water Hydrology

The discharge pattern for the Upper Columbia Subregion is characterized by minimum flows during the fall and winter. Peak flows of most streams occur between April and July. Maximum flow in the Columbia is generally in late May or June. Table 32 summarizes monthly discharge data for selected stations.

From the standpoint of waste discharge control, the low-flow months of August and September are the most critical. One-in-ten-year low flows are used as a basis for establishing critical low flows. These data for selected stations are presented in table 33.

Table 32 - Mean Monthly Stream Discharge, Subregion 2 (12)

Stream Location	Jan.	Feb.	March	April	May	June (CFS)	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
Columbia River at Int'l Boundary	97,100	89,400	67,400	84,500	126,000	145,400	19,700	103,000	80,000	77,900	71,800	86,400	95,800
Kettle River near Laurier, Wash.	526	544	894	5,294	12,362	8,518	2,567	800	661	688	774	660	2,852
Colville River at Kettle Falls, Wash.	197	257	466	881	698	343	149	82	85	111	146	175	299
Columbia River at Grand Coulee Dam	106,400	125,300	102,700	111,800	131,200	120,700	116,400	94,100	85,000	81,700	77,100	94,700	103,900
Okanogan River at Okanogan Falls, B.C.	442	416	441	527	734	768	719	589	516	482	475	480	549
Similkameen River near Nighthawk, Wash.	560	616	657	2,227	8,442	8,208	2,817	907	596	221	913	761	2,286
Okanogan River near Tonasket, Wash.	1,151	1,210	1,249	2,840	9,059	9,217	3,491	1,329	1,017	1,257	1,512	1,394	2,894
Methow River at Twisp, Wash.	306	326	436	1,687	5,188	4,874	1,691	470	292	382	472	387	1,376
Chelan River at Chelan, Wash.	1,719	1,611	1,262	1,094	1,903	3,746	3,260	2,027	1,964	1,854	1,805	1,788	2,003
Wenatchee River at Peshastin, Wash.	1,277	1,301	1,577	3,838	8,533	8,482	4,428	1,387	752	1,167	1,727	1,668	3,010
Crab Creek at Irby, Wash.	112	316	308	155	63	65	31	22	15	13	14	36	95
Columbia River below Priest Rapids Dam	113,200	132,100	108,600	119,000	147,900	147,200	132,800	102,400	91,800	87,800	84,700	101,700	114,100

Table 33 - One-in-Ten-Year Low Flows, Subregion 2 1/ (12)

Stream and Location	One-in-Ten-Year Low Flow (cfs)
Columbia River at International Boundary	42,000
Kettle River near Laurier, Washington	170
Colville River at Kettle Falls, Washington	270
Columbia River at Grand Coulee Dam	54,000
Okanogan River at Okanogan Falls, B.C.	35
Similkameen River near Nighthawk, Washington	260
Okanogan River at Tonasket, Washington	370
Methow River at Twisp, Washington	180
Chelan River at Chelan, Washington	120
Wenatchee River at Peshastin, Washington	390
Crab Creek at Irby, Washington	6
Columbia River below Priest Rapids Dam	65,000

1/ Period of 1 month.

Impoundments and Stream Regulation

Impoundments on the upper Columbia River include Franklin D. Roosevelt Lake, Rufus Wood Lake, Wells, Entiat Lake, Rock Island, Wanapum, and Priest Rapids. Most of these dams are principally for hydroelectric power production, although Franklin D. Roosevelt Lake provides flood control and irrigation; and Wanapum and Priest Rapids provide flood control and recreation. Major reservoirs on tributaries are Lake Chelan on the Chelan River and Potholes Reservoir on Crab Creek. No storage is authorized for water quality control, but incidental benefits result from releases for other purposes.

The series of impoundments on the Columbia River has an important effect on the water temperature regimen. Franklin D. Roosevelt Lake exercises the most significant influence on stream temperature. Regulation by this reservoir has tended to lower temperatures during summer and raise them during fall. The relatively shallow reservoirs located downstream from Grand Coulee Dam (forms Franklin D. Roosevelt Lake) tend to raise water temperature during the summer months and lower them during the fall months. Maximum temperature increases will generally occur during August. The impoundments cause little water temperature changes in September or October. Studies have shown that if releases from Franklin D. Roosevelt Lake are from the upper or intermediate layers, it is probable that the average August temperature at Priest Rapids will exceed by about 2.5°F. (1.4°C.)

the temperatures which existed prior to the impoundments. However, several times in recent years the release of water from bottom layers of Franklin D. Roosevelt Lake to supply cooling water requirements of the Hanford operation, has resulted in a reduction in summer stream temperatures at Priest Rapids. It is reported that temperature reductions at Richland in the order of 4°F. (2.2°C.) have been accomplished by selective withdrawals from Franklin D. Roosevelt Lake.

Ground-Water Characteristics

There are two major aquifer units in the Upper Columbia Subregion capable of yielding large supplies of water to wells. Alluvial and glacial deposits are most important north and northwest of the Columbia River; basalt of the Columbia River group is the most important south of the Columbia River.

The most abundant supply of ground water is available in the southern Columbia Plateau area. Seepage from the irrigation projects has greatly increased the amount of ground water in this area, and there are now several areas where the ground-water table is within 30 feet of the surface. Yields of over 500 gpm are commonplace from this aquifer. The ground-water yields are smaller in the remainder of the area south of the Columbia and Spokane Rivers, but are generally greater than 50 gpm. Yields over 500 gpm are also available along the Okanogan River Valley and along the main stem of the Columbia below Grand Coulee Dam. With the exception of yields from 50 to 500 gpm available along other river valleys, the ground-water yields are generally less than 50 gpm in the remainder of the subregion.

Ground-water quality is generally excellent in most areas. In the alluvial and glacial deposit aquifer units, the dissolved solids generally range from 200 to 500 mg/l; and the water is generally free of any troublesome trace elements or constituents. In the Columbia River basalt, ground-water quality is also generally adequate. However, the Moses Lake-Potholes area and the Mesa-Eltopia area in the Columbia Plateau show serious water quality problems. Dissolved solids concentrations of 1,250 mg/l and nitrate-nitrogen concentrations of 180 mg/l have been reported.

A more detailed discussion of ground water in Subregion 2 is presented in Appendix V.

Pollution Sources

The municipal and industrial waste loadings and discharges, in population equivalents, in the Upper Columbia Subregion are summarized in table 34.

Table 34 - Summary of Municipal and Industrial Waste Treatment, Subregion 2[1/]

	Municipal Waste Treatment					Industrial Waste Treatment			
	Secondary	Primary	Lagoons	Other	Total	Food Products	Wood & Lumber Products	Primary Metals	Total
OTHER									
Number of Facilities	18	4	15	5	42	25	4	5	34
Population Served	33,940	18,100	26,540	1,860	80,440				
P. E. Produced	40,970	21,400	30,210	1,860	94,440	1,871,140	4,500	Inorganic	1,875,640
P. E. Discharged	6,400	12,100	135	600	19,235	17,800	1,700		19,500
% Removal Efficiency	85	44	100	68	80	99	62		99
TRI-CITIES SERVICE AREA									
Number of Facilities	1	2	0	0	3				
Population Served	26,000	28,500	0	0	54,500				
P. E. Produced	33,000	34,000	0	0	67,000				
P. E. Discharged	4,800	25,000	0	0	29,800				
% Removal Efficiency	85	27	--	--	56				
TOTAL									
Number of Facilities	19	6	15	5	45	25	4	5	34
Population Served	59,940	46,600	26,540	1,860	134,940				
P. E. Produced	73,970	55,400	30,210	1,860	161,440	1,871,140	4,500	Inorganic	1,875,640
P. E. Discharged	11,200	37,100	135	600	49,035	17,800	1,700	-	19,500
% Removal Efficiency	85	33	100	68	70	99	62		99

1/ FWPCA Inventory of Municipal and Industrial Wastes, Upper Columbia Subregion, 1968.

At present, municipalities and industries produce wastes equivalent to those from a population of 2.04 million persons. Of this total, 91.6 percent is generated by the food-processing industry, 7.9 percent by municipalities, and 0.5 percent by the lumber and wood products industry.

Waste treatment and other means of waste reduction decrease the total organic load to the subregion's waters by about 97 percent so that only 68,500 population equivalents actually reach waterways. Of this total, 49,035 PE are released by municipalities, and 19,500 PE are discharged by industries.

The Hanford Atomic Works is an important source of radiological wastes and thermal pollution. The radionuclides discharged pose a possible health hazard, and the heat releases increase water temperatures which hinder anadromous fish migration and inhibit spawning.

Other sources of pollution include wastes from the rural-domestic population, irrigation, agricultural animals, land use, recreation, and natural sources.

Municipalities

Approximately 134,940 persons, or 54 percent of the Upper Columbia Subregion population, are served by municipal waste treatment facilities. Of the 45 municipal waste systems, 19 presently have secondary treatment; however, at least two of these facilities need expansion to handle current loads. Five of the six primary treatment plants must be upgraded to secondary treatment to meet minimum requirements of the Washington Water Pollution Control Commission. Only one of the 15 lagoons discharges wastes to streams. The remainder of the lagoons are of the non-overflow type. Five communities provide septic tanks, and three of these discharge to land or non-overflow lagoons. The other two communities must convert to secondary treatment or the equivalent to meet minimum standards of the Washington Water Pollution Control Commission.

In general, municipal waste treatment practices are adequate. An average reduction of about 70 percent of the biochemical oxygen-demanding wastes is accomplished, resulting in a discharge of 49,035 PE to waterways. The municipal waste loadings are usually small and scattered throughout the subregion. Significant waste releases occur only in the Tri-Cities, Wenatchee, Moses Lake, and Okanogan-Omak areas. Of these, the Tri-Cities and Wenatchee areas account for 42 and 11 percent of the total municipal waste loading.

With the present level of waste treatment, few cases of serious water degradation have resulted from municipal sources, since there are generally adequate quantities of water available to assimilate wastes released in most areas. Even in the Tri-Cities area, where about 30,000 PE are discharged from the primary plants at Kennewick and Pasco and the secondary facility at Richland, there is no measurable effect on the Columbia River. The only basins which could have a shortage of water for assimilating wastes are the Okanogan, Colville, and Crab Creek. However, the practices of secondary treatment in the Okanogan Basin and of non-overflow lagoons and land disposal in the Colville and Crab Creek Basins tend to minimize water quality problems.

Industries

Industrial waste treatment practices in the Upper Columbia Subregion are generally excellent. An average reduction of 99 percent of the biochemical oxygen-demanding waste load is accomplished. The organic industrial waste production, equivalent to that from a population of 1.88 million persons, is primarily from the food products industry concentrated in the Columbia Basin

Project (CBP) area. About 99 percent of the total industrial waste produced originates in this area. Only about 17,800 PE are released to waterways by the food products industry. In addition, the wood and lumber products industry contributes minor organic waste loadings, and the primary metals industry is a source of inorganic wastes.

The seasonal operation of the food products plants causes variability in volume and strength of wastes. The plants are generally in peak operation from June through March. Non-overflow lagoons or primary settling followed by land application of the effluent by various methods of irrigation are the principal means of waste disposal. Localized odor problems associated with lagoons for starch, sugar, and potato wastes have been reported. In the Wenatchee area, about 12,500 PE are released to the Columbia River by the food products industry. In addition, organic waste loadings of 3,800 and 1,000 PE are discharged to the Wenatchee and Okanogan Rivers, respectively, by a number of apple packers and processors.

The lumber and wood products industry is a relatively minor waste source. An organic loading of only about 1,700 PE is discharged to streams. However, inorganic waste discharges can cause aesthetic problems and nuisance conditions. A lumber company at Oroville, which releases an organic loading of 1,000 PE to the Similkameen River, and a lumber company at Brewster must install primary treatment to satisfy Washington Water Quality Standards. Organic waste loading discharged to the Columbia River by a fiber company at Wenatchee amounts to a population equivalent of 100. The Washington Water Quality Standards Enforcement Program lists this plant as in need of improved operation and outfall extension.

Little data are available as to the nature of effluents from primary metals operations. However, the mining industry is not considered to be a major water pollution source. An aluminum company near Wenatchee presently provides primary treatment of industrial wastes. The Washington Water Quality Standards require that the company expand present facilities and upgrade to secondary treatment or the equivalent.

Rural-Domestic

Approximately 115,300 persons, or 46 percent of the subregion population, are served by individual waste disposal systems. In general, septic tanks and some type of subsurface drainage are used for waste disposal.

The actual waste load reaching waterways from rural-domestic sources is not considered to be large. However, rural-domestic wastes are presently discharged to several lakes and reservoirs in the subregion, including Lake Chelan and Wenatchee Lake. These lakes are used extensively as recreational areas, with private resorts and homes concentrated in the area. Septic tank drainages and other domestic discharges to the lakes tend to supply nutrients which stimulate algal growths. In addition, numerous septic tank effluents drain directly into the Okanogan and Colville Rivers.

Irrigation

Irrigation practices are a significant source of pollution in two areas of the subregion--the Columbia Basin Project (CBP) area and the Okanogan Valley. The irrigation return flows from the CBP have not had a significant effect on the chemical quality of the Columbia River but have been a primary influence on water quality within the CBP area. Within the area, as return flows accumulate and enter the stream system, there is a marked increase in total solids, nutrients, coliform bacteria, and temperature. Irrigation return flows also contribute to the heavy algal growths in Moses Lake by supplying nutrients. There are also a number of other nutrient sources entering the lake, so that the nutrient contribution by return flows is not readily identifiable. Irrigation return flows have also raised ground-water levels in some areas and have contributed to changes in ground-water quality. The effect of irrigation on the ground-water quality is variable, but in most places where, prior to irrigation, the water was not highly mineralized and where the water table has shown a significant variation, quality has deteriorated. Samples showing total dissolved solids ranging between 500 and 1,250 mg/l; and nitrate-nitrogen concentrations up to 180 mg/l have been reported; however, it should be noted that some wells exhibited high dissolved solids and nitrate-nitrogen concentrations even before irrigation started. The higher values are often found at shallow depths, indicating the effects of rising ground-water levels as a result of irrigation.

Of primary concern from a health standpoint is the high nitrate concentration which exceeds, in some areas, the maximum concentration of 10 mg/l nitrate-nitrogen, recommended by the PHS Drinking Water Standards. Nitrate-nitrogen concentrations above 10 mg/l can cause "blue babies" due to oxygen starvation of the bloodstream.

In the Okanogan Valley, irrigation return flows from Canada and Washington have contributed to the mineral content and temperature of the Okanogan River, although the total effect from these irrigation return flows cannot be determined from available data.

Water diversions from the Okanogan River reduce summertime flows and thereby reduce the assimilative capacity and tend to increase the temperature of the river.

Agricultural Animals

Agricultural animals are considered to be a major waste source in the Upper Columbia Subregion, although the impact of animal wastes on water quality is difficult to determine. The large population of animals produces an estimated waste production equivalent to that from a population of 2.6 million persons. An estimated 95 percent of the waste production is removed by soil filtering and natural decomposition on land, so that about 130,000 PE eventually reach waterways.

Generally the waste loading attributed to the animal population does not represent a meaningful figure since the animal population is diffused throughout the subregion. However, numerous feedlots in the Columbia Plateau area can be sources of concentrated waste loadings. On Crab Creek, coliform counts as high as 230,000 organisms/100 ml have been reported, which are attributed to feedlot and pasture runoff since there are no municipal waste discharges to Crab Creek. The operation of a feedlot resulted in a fish kill in Crab Creek during December 1966. Potato starch, which was being used as a food supplement for beef cattle, reached the stream because of improper management techniques. The stream bottom below the feedlot was covered with slime, and the water was turbid. Approximately 2,000 game and non-game fish were killed in a 2-day period.

Other Land Uses

Distinguishing the water quality impacts of human use of land from natural occurrences is difficult; but in a watershed like the Upper Columbia, where extensive use of land for agriculture is a major facet of the economy, uncontrolled land drainage constitutes an influence on water quality due to increases in nitrates, turbidity, sedimentation, and persistent toxic environmental control chemicals. The production and transport of sediment results in the most significant water quality impairments resulting from land use. Generalized sediment yields range between 0.02 and 1.5 acre-feet per square mile per year, with the greatest yield from dry farmland areas. The larger sediment yields, such as those near Douglas Creek, are caused either by erosion of the surface soil when the underlying ground is frozen or by high-intensity rainstorms in the summer months.

Present Water Quality

In general, streams of the Upper Columbia Subregion are relatively free of pollution. In some areas, however, water quality has deteriorated, through either natural or man-made pollution; and this deterioration has impaired the use of the stream. The waters of the Upper Columbia are generally good from the standpoint of dissolved oxygen, color, turbidity, hardness, and dissolved solids. Problems do occur in some reaches and seasons with respect to temperature, radioactivity, and bacterial and biological contamination.

The Washington Water Pollution Control Commission maintains regular water quality monitoring programs for major tributaries of the Columbia River and for the Columbia at Northport and below Priest Rapids Dam. In addition, FWQA Water Surveillance System Stations are located on the Columbia at Wenatchee and Richland. The Washington Water Quality Standards tentatively propose additional water quality monitoring stations on the Columbia at Hanford, Brewster, and Bridgeport.

Main Stem Columbia

A summary of mean and extreme values for important water quality parameters for selected stations in the subregion is presented in table 35.

Mean dissolved oxygen levels in all reaches of the Columbia River from Northport to Richland average above 10 mg/l. The minimum dissolved oxygen concentration reported has been 6.8 mg/l at Pasco. The Washington Water Quality Standards Enforcement Program provides that no wastes be discharged into the Columbia River which would cause dissolved oxygen levels to fall below 9.5 mg/l above Grand Coulee Dam or 8.0 mg/l below Grand Coulee Dam. At present, any dissolved oxygen concentrations below the State standards can be attributed to natural causes, and no detrimentally low DO levels have occurred.

Coliform counts in the form of MPN/100 ml or MF/100 ml are used as a measure of bacterial pollution from warm-blooded animals and, therefore, as an indication of the relative safety of contact with, or ingestion of, water. Quality monitoring stations at Northport and below Priest Rapids Dam have average coliform counts of 385 and 131/100 ml, respectively. Washington Water Quality Standards require that total coliform organisms shall not exceed median values of 50/100 ml from the International Boundary to Grand Coulee Dam and shall not exceed 240/100 ml from Grand Coulee Dam to the Oregon-Washington boundary.

Table 35 - Summary of Water Quality Data, Subregion 2[1/]

	River Mile	D.O. (mg/1)	T (^{o}C)	Coliform MPN/ 100ml	ph	Color PT-CO Units	Hard. (mg/1)	Turb. (JTU)	TDS (mg/1)	Ortho PO_4 (mg/1)	NO_3-N (mg/1)
MAIN STEM COLUMBIA											
Northport, Washington											
Mean		11.5	9.8	385	7.6	4	78	17	--	.05	.05
Min		10.4	1.6	240	6.6	0	50	0	--	.01	.00
Max		12.4	17.5	560	8.4	25	159	32	--	.18	.11
Wenatchee, Washington											
Mean		11.8	11.0	310	8.0	5	66	4	--	.03	.07
Min		8.0	2.5	2	6.9	0	50	0	--	.01	.00
Max		15.5	21.6	7,300	8.6	25	112	25	--	.04	.14
Columbia River below Priest Rapids Dam											
Mean		11.9	11.4	131	7.7	5	69	3	--	.08	.10
Min		9.5	3.0	0	7.5	0	62	0	--	.03	.02
Max		14.0	18.5	430	7.9	5	81	20	--	.15	.27
Columbia River, Pasco, Washington											
Mean		10.8	12.2	182	8.1	8	73	15	--	.01	.19
Min		6.8	3.0	1	6.8	0	40	0	--	.01	.05
Max		14.3	22.0	4,800	8.6	68	90	140	--	.02	.37
Columbia River below Rock Island											
Mean		12.3	10.6	691	7.8	8	82	4	--	--	.10
Min		9.8	1.5	10	7.2	3	58	1	--	--	.01
Max		15.9	18.0	8,000	8.4	15	132	32	--	--	.19
TRIBUTARIES											
Kettle River near Barstwo, Washington	706.4-10.3										
Mean		11.2	9.8	603	7.8	7	68	2	94	0.01	0.05
Min		7.9	0.0	0	6.9	0	20	0	39	0.00	0.00
Max		14.5	25.0	11,000	8.7	30	110	10	141	0.07	0.11
Colville River at Kettle Falls, Wash.	695.0-5.3										
Mean		10.5	10.4	4,774	7.9	9	165	25	204	0.20	0.37
Min		7.3	0.0	0	7.6	5	108	5	141	0.01	0.02
Max		13.8	24.0	46,000	8.7	30	202	140	260	0.51	1.49
Sanpoil River at Keller, Wash.	616.0-12.2										
Mean		11.1	8.8	901	7.8	6	85	3	128	0.14	0.06
Min		7.8	0.3	0	7.3	0	51	0	98	0.03	0.00
Max		13.6	25.0	11,000	8.8	20	106	15	156	0.95	0.16
Okanogan River at Oroville, Wash.	533.5-81.9										
Mean		11.0	11.5	52	8.0	4	126	1	168	0.02	0.05
Min		8.4	1.2	0	7.4	0	109	0	149	0.00	0.02
Max		13.2	26.0	430	8.5	10	136	5	178	0.04	0.11
Similkameen River at Oroville, Wash.	533.5-77.6-5.2										
Mean		11.0	11.7	99	7.7	6	72	3	100	0.02	0.03
Min		8.2	0.8	0	7.1	0	32	0	52	0.01	0.00
Max		14.5	23.0	930	8.1	20	99	15	132	0.09	0.09

Table 35 (Continued)

	River Mile	D.O. (mg/l)	T (°C)	Coliform MPN/ 100ml	ph	Color PT-CO Units	Hard. (mg/l)	Turb. (JTU)	TDS (mg/l)	Ortho PO_4 (mg/l)	NO_3-N (mg/l)
Okanogan River near Brewster, Wash.	533.5-1.4										
Mean		10.9	11.5	4,699	7.8	6	101	6	137	0.05	0.05
Min		5.8	0.0	0	7.1	0	38	0	59	0.00	0.00
Max		15.4	28.1	240,000	8.4	20	147	40	205	0.16	0.18
Methow River at Pateros, Wash.	523.9-0.5										
Mean		11.5	9.1	457	7.8	3	73	1	96	0.02	0.13
Min		9.3	0.0	0	6.9	0	28	0	45	0.00	0.00
Max		14.2	20.5	9,300	8.4	10	101	10	130	0.20	0.32
Chelan River at Chelan, Wash.	503.2-2.9										
Mean		10.5	12.7	259	7.2	2	20	1	32	0.01	0.04
Min		8.6	4.5	0	7.0	0	19	0	27	0.00	0.00
Max		12.1	23.8	2,400	7.5	5	21	10	38	0.04	0.09
Entiat River near Entiat, Wash.	483.7-6.2										
Mean		11.8	8.4	775	7.5	3	31	2	55	0.02	0.05
Min		8.9	0.0	0	6.8	0	16	0	30	0.00	0.00
Max		14.2	19.6	11,000	8.0	5	47	10	79	0.07	0.16
Wenatchee River near Leavenworth, Wash.	468.4-35.5										
Mean		10.9	8.1	667	7.1	5	13	1	28	0.01	0.04
Min		4.2	0.1	0	5.8	0	8	0	20	0.00	0.00
Max		13.6	22.2	24,000	7.4	10	16	5	37	0.03	0.20
Wenatchee River at Wenatchee, Wash.	468.4-1.1										
Mean		11.9	9.5	1,047	7.4	5	25	2	42	0.02	0.09
Min		9.1	0.0	0	6.8	0	12	0	23	0.00	0.02
Max		16.4	25.3	11,000	8.8	10	43	10	66	0.20	0.18
Crab Creek at Irby, Wash.	410.8-113.7										
Mean		11.6	8.4	738	8.1	11	143	92	234	0.44	1.37
Min		9.0	1.0	36	7.6	5	99	0	187	0.29	0.75
Max		13.6	16.8	2,900	8.5	50	175	410	280	0.74	2.49
Crab Creek near Moses Lake, Wash.	410.8-66.2										
Mean		12.1	10.4	20,444	8.0	11	184	75	323	0.25	0.84
Min		9.7	1.0	0	7.2	5	89	0	175	0.10	0.45
Max		16.0	22.0	230,000	8.8	25	216	400	400	0.49	1.27
Crab Creek near Smyrna, Wash.	410.8-17.8										
Mean		11.0	13.9	1,779	8.0	9	212	47	533	0.33	0.63
Min		6.6	0.5	0	7.5	5	164	10	396	0.16	0.09
Max		16.6	29.0	24,000	8.5	15	260	100	694	0.54	1.60
Crab Creek near Beverly, Wash.	410.8-6.1										
Mean		11.5	-	648	8.4	14	241	-	750	-	0.90
Min		9.5	-	0	8.1	5	210	-	544	-	0.52
Max		13.2	-	2,100	8.7	35	278	-	906	-	1.40

1/ FWPCA STORET, 1968.

One of the significant water quality problems in the Upper Columbia Subregion is that of high temperatures in segments of the main stem of the river and its tributaries. These temperatures occur as a result of impoundments, abnormally low flows, warmed irrigation return flows, and heated cooling waters from the Hanford Atomic Works. These thermal increases in the aquatic environment tend to decrease the natural productivity of cold water species of fish.

Water Quality Standards for the Columbia River from the International Boundary to Grand Coulee are Class AA, and are Class A from Grand Coulee Dam to the Oregon-Washington boundary. Temperature requirements for Class AA waters are:

> "No measurable increases shall be permitted within the waters designated which result in water temperatures exceeding 60°F (FRESH WATER) nor shall the cumulative total of all such increases arising from non-natural causes be permitted in excess of $t = 75/(T-22)$ (FRESH WATER); for purposes hereof 't' represents the permissive increase and 'T' represents the resulting water temperature." (15)

Temperature requirements for Class A waters are:

> "No measurable increases shall be permitted within the waters designated which result in water temperatures exceeding 65°F (FRESH WATER) nor shall the cumulative total of all such increases arising from non-natural causes be permitted in excess of $t = 90/(T-19)$ (FRESH WATER); for purposes hereof 't' represents the permissive increase and 'T' represents the resulting water temperature." (15)

Water temperature levels are compatible with Class AA and Class A requirements from the International Boundary to within a few miles of the headwaters of McNary Pool. The sections of the Columbia downstream from the Hanford Atomic Works are influenced by both natural and non-natural causes which result in temperature rises significantly above the criteria for Class A waters. The water temperature levels rise to 70°F. (21.1°C.) or above during the summer months. Short-term surveys show temperature rises from 2° to 5°F. (1.1 to 2.8°C.) in the vicinity of the Hanford operation.

A significant change in water quality in the Upper Columbia is the increase in radioactivity due to the discharge of radioactive wastes from the Hanford Atomic Works. Battelle-Northwest

and AEC continually monitor radioactivity in the Columbia River at Priest Rapids Dam, Richland, McNary Dam, and Bonneville Dam. The states of Oregon and Washington and the FWPCA also provide frequent sampling of radioactivity. Table 36 summarizes annual average gross beta count for several stations on the Columbia River. Table 37 presents annual average concentrations of several radionuclides at Richland and Bonneville Dam in 1966. Above the Hanford Works, the gross beta count averages only 11 picocuries/liter (pc/l), while it averages 710 picocuries/liter at Pasco, downstream from Hanford in 1964. Since November 1964, the maximum gross beta levels have not exceeded the PHS Drinking Water Standard of 1,000 picocuries/liter. Gross beta activity decreases at McNary and Bonneville Dams as a result of natural radioactive decay, removal from the water by sedimentation, and uptake by aquatic organisms. Radionuclides of particular concern in the Columbia River are zinc-65 and phosphorus-32, since they tend to concentrate in the food chain of organisms in the Columbia River. In 1966, concentrations below Hanford averaged 200 and 140 pc/l, respectively. Zinc-65 and phosphorus-32 are also the only significant radionuclides found in sufficient abundance for measurement beyond the mouth of the Columbia. Oysters in the Willapa Bay area have been found to contain higher concentrations of zinc-65 than other common seafood organisms. In 1966, the Federal Water Pollution Control Administration recommended that zinc-65 and phosphorus-32 wastes be reduced by at least 50 percent.

Table 36 - Annual Average Gross Beta Activity in the Columbia River Subregion 2

Location	1968 Annual Average Gross Beta Count pc/liter	1964 Annual Average Gross Beta Count pc/liter
Northport	5.0 1/	10.8
Wenatchee	5.0 1/	11.9
Pasco	140.5	710.0
McNary	47.0 1/	290.5
Bonneville	41.0 1/	250.2

1/ Represents one sample.

The Columbia River, as it enters the United States from Canada, is a calcium-bicarbonate type water which has an average dissolved solids concentration of approximately 90 mg/l. Samples collected at the International Boundary since 1952 have a dissolved solids range of 71-158 mg/l. The water is moderately hard, ranging from 78 to 159 mg/l hardness. Concentrations of nutrients

and trace elements in the Columbia are generally low. However, annual average phosphate concentrations at Priest Rapids Dam are near the threshold limit (0.025 mg/l PO_4 as phosphorus) for stimulation of algal growth. The main stem of the Columbia River shows little change in mineralization from the International Boundary to the point of its confluence with the Snake River. The effect of incoming tributaries with higher mineralization is partly offset by the contribution of tributaries with lower mineralization. However, the major reason for the uniformity of mineralization in this reach of the main stem is the relative discharge of the Columbia compared with that of its tributaries.

Table 37 - Annual Average Concentrations of Several Radionuclides in the Columbia River--1966, Subregion 2 (1)

Radionuclides	Richland pc/liter	Bonneville Dam pc/liter
Rare Earths + Y	270	- 1/
^{24}Na	2,600	-
^{32}P	140	23
^{51}Cr	3,600	1,300
^{64}Cu	1,400	-
^{65}Zn	200	43
^{76}As	420	-
^{90}Sr	1	-
^{131}I	18	3
^{239}Np	770	-

1/ Indicates insufficient data to supply meaningful annual average.

Supersaturated levels of dissolved nitrogen as high as 140 percent have recently been reported by the Bureau of Commercial Fisheries. The condition persists all along the Columbia River from Grand Coulee Dam to the mouth and presents a threat to migratory salmonids. If the fish are forced from the depths to the surface by barriers to their migration, or pass through significantly higher temperatures in thermal plumes, nitrogen bubbles can form in their bloodstreams, causing nitrogen embolism

similar to "the bends." The supersaturation phenomenon is probably initiated at dam spillways, but the subsequent failure to reach an equilibrium with the atmosphere is unexplained. (3) (24) No specific limits have been set for dissolved nitrogen in State Water Quality Standards. Any amount over saturation may be lethal.

Tributaries

The major tributaries of the upper Columbia are the Similkameen, Okanogan, Kettle, Methow, Chelan, Wenatchee, Sanpoil, Entiat, and Colville Rivers and Crab Creek. Table 35 summarizes important water quality parameters for selected stations in the subregion. The data available indicate that waters are generally suitable for most uses. The most important water quality problems are in Moses Lake, where prolific algal blooms have hindered its recreational development; in the Okanogan and Methow Rivers, where high water temperatures interfere with cold water species of fish; and in the lower Colville, Okanogan, Entiat, and Wenatchee Rivers where total coliform organisms exceed recommended limits.

The Wenatchee, Entiat, Chelan, and Methow Rivers (entering the Columbia from the west) originate in the high elevations of the Cascade Range. The waters in the streams are generally soft (less than 30 mg/l hardness), high in dissolved oxygen, and low in total dissolved solids. The Methow River has slightly greater concentrations of total dissolved solids and has an average hardness of about 73 mg/l. These tributaries are generally of excellent bacterial quality, although the lower Wenatchee and Entiat Rivers have on occasion exhibited high total coliform counts. The median coliform count of the Wenatchee River at Wenatchee exceeds the 1,000 organisms/100 ml limit recommended for safe water-contact recreation.

Those streams which drain the northern and eastern areas of the subregion, including the Okanogan, Similkameen, Sanpoil, Kettle, and Colville Rivers, are more highly mineralized, primarily because irrigation is more extensive, the land is more arid, and the concentration of natural solute is greater. The total dissolved solids are generally greater than 100 mg/l. Average dissolved oxygen levels are above 10 mg/l. The lower Okanogan and Colville Rivers are the only streams with average coliform counts exceeding the recommended limit for water-contact recreation. Summer water temperatures in the Okanogan River during anadromous fish migration periods have at times been high enough (above 78°F.) (25.6°C.) to force salmonid fish to take refuge in the cooler waters of the Columbia River where they are subjected to nitrogen supersaturation problems.

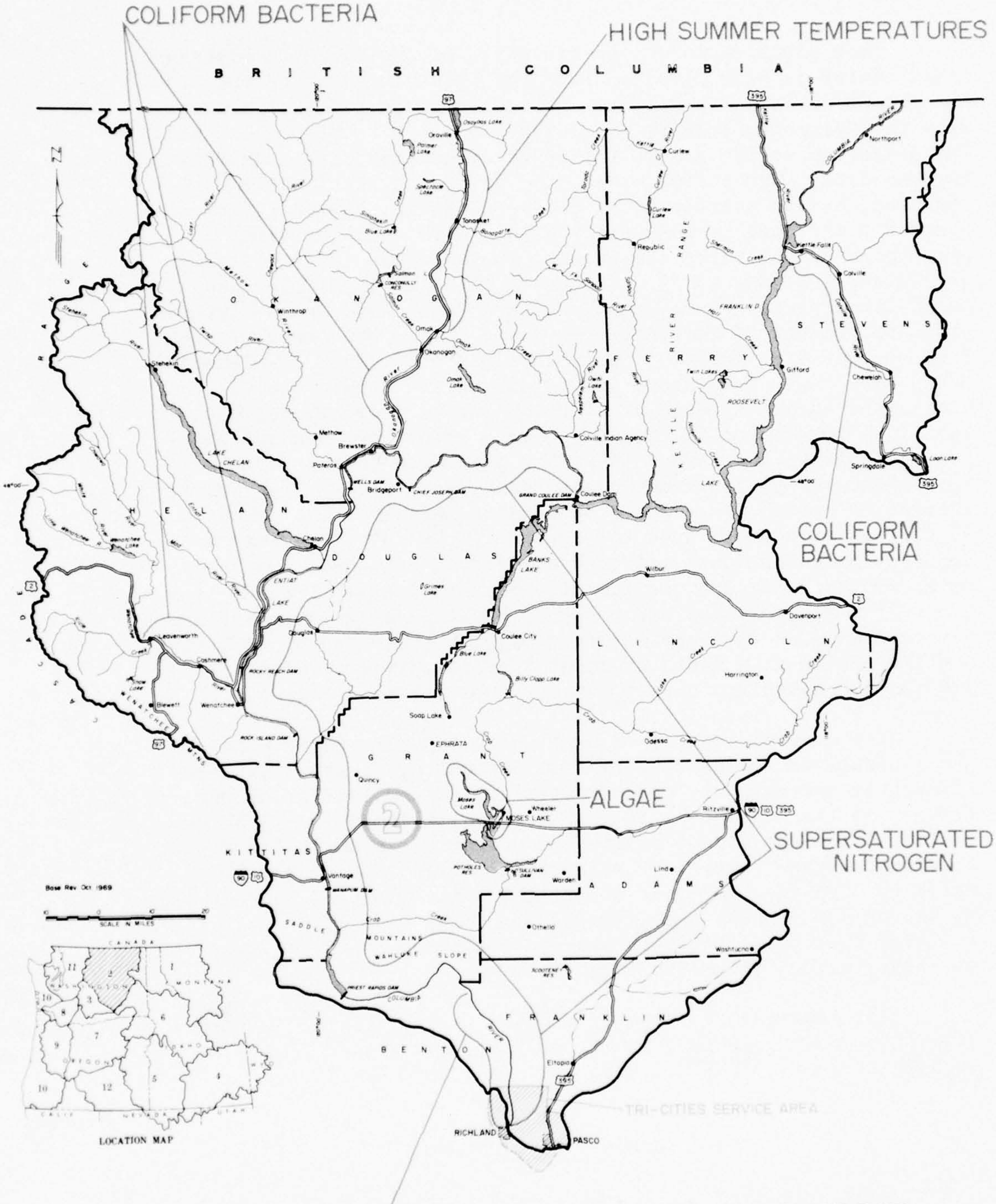
Crab Creek is the major tributary of the Columbia Plateau area. Water is also diverted from the Columbia River to the area for the Columbia Basin Project. The water imported to the area from the Columbia River is of adequate quality to serve all needs. The dissolved solids are in the range of 120-140 mg/l when entering the area. Upper Crab Creek, the natural historic stream in the area, has an average total dissolved solids concentration of about 230 mg/l and is moderately hard. High concentrations of phosphates and nitrates are present in the creek (0.44 mg/l PO_4 as PO_4 and 1.37 NO_3 as N). The creek also has high color and turbidity levels. Upper Crab Creek and Rocky Ford Creek represent about 55 percent of the inflow to Moses Lake. The remainder is from ground-water inflow. Concentrations of dissolved solids in Moses Lake range from about 250 to 450 mg/l. Prolific algal blooms and turbidity have limited the lake's recreational use. The algal production is thought to be a result of abundant phosphate inputs to the lake. The major phosphate sources are the Moses Lake sewage treatment plant, Rocky Ford Creek, Crab Creek, irrigation return flows and ground-water inflows. The profuse algal growths have reduced the appeal of the lake to swimmers and boating enthusiasts although coliform counts have generally remained less than 100 per 100 ml, which indicates little health hazard for recreational use. Algae, however, exert a significant oxygen demand on the lake waters. Samples collected about 2 feet off the bottom at a depth of about 30 feet during the summer of 1963 showed dissolved oxygen ranging from 2.7 to 7.3 mg/l.

The mineral content of Crab Creek below Potholes Reservoir, has a dissolved solids content from 300-350 mg/l, which is significantly increased by ground-water inflow and irrigation return flows. At the confluence of Crab Creek with the Columbia River the mean total dissolved solids concentration is about 750 mg/l. Dissolved oxygen remains at a relatively high level (over 9.5 mg/l) through this reach of the creek. Coliform densities as high as 46,000/100 ml have been reported in lower Crab Creek. It is believed that these bacteria are contributed by cattle pastured on lands through which the stream flows.

The temperature range in Crab Creek is from 70° to 77°F. (21.1° to 25.0°C.) during summer months; however, temperatures as high as 84°F. (28.9°C.) have been reported.

Summary of Problems

A graphical summary of water quality problem areas in the Upper Columbia Subregion is presented in figure 17.



COLUMBIA-NORTH PACIFIC
COMPREHENSIVE FRAMEWORK STUDY

MAJOR WATER QUALITY PROBLEM AREAS

UPPER COLUMBIA SUBREGION 2

1970

FIGURE 17

The summer water temperatures of the Columbia River below the Hanford operation are above recommended State Water Quality Standards. The high water temperatures are a result of natural causes, the series of impoundments on the Upper Columbia, and the Hanford Atomic Works. The Okanogan and Methow Rivers also have high summer water temperatures as a result of natural causes and water diversions.

The Columbia River below Grand Coulee Dam contains supersaturated levels of dissolved nitrogen gas, which causes gas bubbles in fish. The supersaturation phenomenon results from air-entrainment in spillways, but its persistence throughout the Columbia River is not understood.

Surveillance of ground-water quality in the Columbia Basin Project area is needed to protect individual domestic water supplies. Nitrate-nitrogen concentrations in some areas have reached levels of 180 mg/l. The PHS Drinking Water Standards recommend a maximum limit of 10 mg/l nitrate-nitrogen for domestic water sources to protect against the infant disease "methemoglobinemia."

Excessive algal growths have interfered with recreational and fisheries uses of Moses Lake. The profuse algal blooms are thought to be a result of nutrient inflow from ground-water domestic wastes, irrigation returns, and several tributaries.

Total coliform bacteria counts in excess of recommended criteria occur in the lower reaches of the Okanogan, Colville, Entiat, and Wenatchee Rivers. Inadequately treated municipal wastes and septic tank drainages are generally responsible for the problem.

FUTURE WATER QUALITY MANAGEMENT NEEDS

Based on the projected economic development of the Upper Columbia Subregion, the population is expected to increase from 250,200 in 1965 to 548,000 in 2020. This represents an increase of 119 percent for the subregion, as compared with 121 percent for the region.

Figure 18 shows the projected subbasin population for the years 1980, 2000, and 2020. The projected service area populations for municipal and rural categories are presented in table 38.

Industrial development will continue to be based on agricultural, food-processing, and associated industries. Food production is expected to increase 2.5 times as more lands are

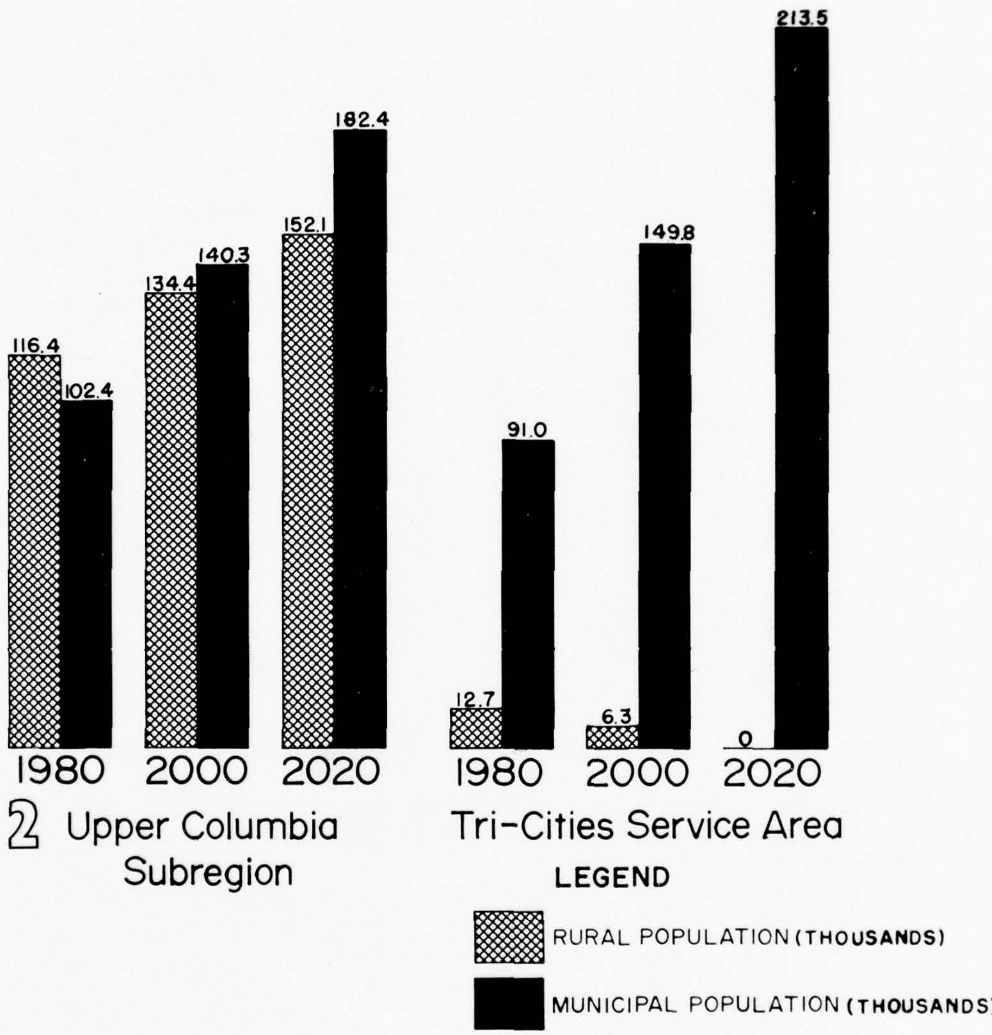


FIGURE 18. Projected Population, Subregion 2

irrigated. The pulp and paper industry and the lumber and wood products production are expected to expand significantly; however, only limited expansion of the primary metals industry is likely.

Table 38 - Projected Population, Subregion 2 1/

	1980	2000 (thousands)	2020
Tri-Cities Service Area	103.7	156.1	213.5
Municipal	91.0	149.8	213.5
Rural	12.7	6.3	-
Other	218.8	274.7	334.5
Municipal	102.4	140.3	182.4
Rural	116.4	134.4	152.1
Total Subregion	322.5	430.8	548.0
Municipal	193.4	290.1	395.9
Rural	129.1	140.7	152.1

1/ Differences between totals in this table and source are due to differences in subregion boundaries. The source is based on economic boundaries and this table is based on hydrologic boundaries. The municipal population is defined as that population discharging wastes to a municipal sewerage system. The rural population is defined as the residual.

Future Waste Production

Municipal

The projected municipal raw waste production for the Upper Columbia Subregion is presented in table 39. The population served by municipal sewers and treatment facilities is expected to increase from 53 percent in 1965 to 72 percent by the year 2020. The Tri-Cities Service Area will continue to produce approximately half of the subregion's municipal raw waste.

Table 39 - Projected Municipal Raw Organic Waste Production, Subregion 2 1/

	1970	1980	2000	2020
		(1,000's P.E.)		
Tri-Cities Service Area	83.3	113.8	187.2	266.9
Other	109.7	128.0	175.4	228.0
Total Subregion	193.0	241.8	362.6	494.9

1/ A factor of 1.25 was applied to the municipal population components to account for the effects of small commercial establishments and other urban activities which add to municipal waste loads.

Industrial

Projected raw organic waste production for the major industrial categories are presented in table 40 for the years 1980, 2000, and 2020. By the end of the projection period, it is expected that industries will produce approximately 48 percent of the subregion's total organic waste production. The food products industry will continue to be the largest organic waste source, contributing approximately 91 percent of the industrial waste production. The pulp and paper industry and the lumber and wood products industry are expected to expand significantly in the Wenatchee area. Only limited expansion is anticipated in the primary metals industry, but aluminum production is expected to increase a great deal.

Table 40 - Projected Industrial Raw Organic Waste Production, Subregion 2 (5) (17) 1/

	1970	1980	2000	2020
		(1,000's P.E.)		
Food Products				
Grant and Adams Counties	1,899.4	2,547	4,050	6,130
Chelan County	300.0	360	510	710
Okanogan County	45.0	90	125	180
Other	3.0	3	5	10
	2,247.4	3,000	4,690	7,030
Pulp and Paper				
Chelan County	0.5	200	400	680
Lumber and Wood Products				
Okanogan County	3.8	4.5	5.1	5.3
Chelan County	1.2	1.6	1.9	2.0
	5.0	6.1	7.0	7.3
Total	2,252.9	3,206.1	5,097.0	7,717.3

1/ Base data from FWPCA inventory of municipal and industrial wastes, Upper Columbia Subregion, 1965.

The most serious case of heat pollution in the Upper Columbia Subregion is the Hanford Atomic Works. Short-term surveys have revealed temperature rises of from 2° to 5°F. (1.1 to 2.8°C.) near the Hanford outfall and levels of 70°F. (21.1°C.) downstream in summer. Likewise, the Hanford Atomic Works is the major producer of radioactive waste in the

subregion. The effluent is high in zinc-65 and phosphorus-32, both of which pose a threat to health as well as to wildlife and aquatic flora and fauna.

Rural-Domestic

The projected rural-domestic waste production is summarized in table 41 for the years 1980, 2000, and 2020. The rural-domestic waste production was assumed to be equal to the rural population component shown in table 38.

Table 41 - Projected Rural-Domestic Raw Organic Waste Production, Subregion 2

	1970 1/	1980	2000	2020
		(1,000's P.E.)		
Total Subregion	119.9	129.1	140.7	152.1

1/ Interpolated from 1965 data and 1980 projections.

Rural development is expected to occur around lakes and reservoirs and in areas where lands are brought under irrigation. In lakes such as Lake Chelan and Wenatchee Lake, rural wastes could result in localized algal problems and bacterial contamination.

Irrigation

In 1966, there were approximately 729,000 acres of irrigated land, which required an annual diversion rate of 4.4 acre-feet per acre. Irrigated acreage is projected to increase to 1,280,000 acres by 1980; 1,490,000 acres by 2000; and 1,920,000 acres by 2020. The diversion rate is expected to decrease to approximately 3.6 acre-feet per acre, and therefore the actual diversion of water for irrigation will increase by only about 2.1 times by 2020. As a result, more efficient use and application of water will need to be practiced, which, in turn, will generally minimize irrigation as a pollution source. Irrigation developments will still need to be studied individually to evaluate the impact on water quality.

Other Land Uses

Projections of land use in the subregion, by major types of land use, are shown in table 42. The projections show an increase in land area for croplands and a decrease for range and pastureland. Increased use of fertilizers on crop and pastureland will create a potential source of nutrients, which will continue to aggravate the algal problems in lakes and streams. Pesticides applied to these lands can also drain into the lakes and streams and have detrimental effects on the ecology.

Table 42 - Projected Land Use by Major Types of Land, Subregion 2 (5)

Land Use	1966	1980	2000	2020
		(thousand acres)		
Cropland	3,309	3,451	3,345	3,300
Irrigated	(707)	(1,242)	(1,448)	(1,866)
Nonirrigated	(2,602)	(2,809)	(1,897)	(1,434)
Forest	5,652	5,624	5,653	5,674
Range 1/	4,584	4,363	4,360	4,300
Other 2/	536	570	616	662
Total	14,081	14,008	13,974	13,936

1/ Does not include forest range.
2/ Includes barren land, roads, railroads, small water areas, urban and industrial areas, farmsteads, airports, etc.

Agricultural Animals

The raw organic waste production by the livestock population in the subregion is expected to be equivalent to that from a population of 4,400,000 in 1980; 5,900,000 in 2000; and 7,700,000 in 2020. This is approximately 48 percent of the total organic waste production for the subregion. Most of the waste remains on the land and decomposes by natural processes. It is expected that a larger percentage of the cattle will be on feedlots by the year 2020, as compared to those presently on lots. Animals concentrated in feedlots along streams cause accelerated erosion as well as intensifying the potential coliform bacteria, nutrients, and biochemical oxygen demand in the water.

Recreation

The projected raw waste production by recreation activities in the subregion is summarized as follows:

Year	Population Equivalents 1/
1970	76,000
1980	103,000
2000	189,000
2020	345,500

1/ Bureau of Outdoor Recreation and U.S.D.A. Forest Service Projections for total man recreation days (TMRD).

In the determination of wastes from recreation activities, the population equivalent is based on the total average recreational days. The values represent the daily raw waste production for a typical summer weekend.

Other Factors Influencing Quality

Soil erosion on agricultural and deforested lands and from construction activities causes siltation and turbidity in the watercourses receiving drainage from these areas. Commercial sand and gravel producers are another source situated near the urban areas.

The Upper Columbia Subregion contains some of the most productive lead and zinc deposits in the State of Washington as well as other significant deposits of heavy metals. Economic conditions cause mining operations to be sporadic, creating a situation that does not lend itself to effective waste control practices.

Streamflow management can also have an impact on water quality. When streamflows diminish, water quality suffers drastically. Management programs reflect the public attitude. Achievement of good water management and the flows needed can be realized only with the support of the people, fully informed and aware of the problems and their solutions.

Quality Goals

Subregion quality objectives are based on water quality standards established for the State of Washington. In establishing the water quality standards, each stream was classified as to its intended use, and criteria were set to protect these uses through quality levels which must be maintained. In addition, the standards incorporate an anti-degradation provision by requiring that waters whose existing quality is better than the established standards be maintained at the existing higher quality level. Also, the standards require that the highest and best practicable treatment under existing technology be applied

to all waste discharges. The common parameters generally used are dissolved oxygen concentrations, temperature, turbidity, and coliform density.

The water quality standards are summarized in table 43.

Table 43 - Water Classification and Criteria, Subregion 2 (22)

Water Quality Standards	Class AA Extraordinary	Class A Excellent	Class B Good
Coliform	50 MPN	240 MPN	1,000 MPN
Dissolved oxygen	9.5 mg/1	8.0 mg/1	6.5 mg/1
Temperature 1/	60°F.	65°F.	70°F.
pH	6.5-8.5	6.5-8.5	6.5-8.5
Turbidity	5 JTU	5 JTU	10 JTU
Aesthetic values	Shall not be impaired by the presence of materials or their effects, excluding those of natural origin, which offend the sense of sight, smell, touch, or taste.		

1/ For all classes, the permissible increase in temperature over natural conditions is less than 1.8°F. (1.0°C.)

The above uses and criteria are not inclusive, and the water quality standards should be consulted for specific information. A copy of the water quality standards is available upon request from the Washington Water Pollution Control Commission.

MEANS TO SATISFY DEMANDS

Preserving water quality in the Upper Columbia Subregion to adequately support the river system's function will require a coordinated program of waste reduction, flow regulation, application of waste-controlling techniques, and development of a system of cooperative management of the subregion for pollution control. The achievement and preservation of good water quality are based upon people operating within the context of a political, social, and economic system. The attainment of adequate water quality will require an efficient, adequately staffed and funded water quality management system for attacking the water pollution problem.

Waste Treatment

Future Waste Discharges

Water quality control is largely dependent on providing adequate municipal and industrial waste treatment. If additional requirements and actions become necessary to attain desired quality levels, the standards and implementation plan will have to be revised accordingly.

For the purpose of this study, it is assumed that treatment efficiencies of 85 percent for 1980, and 90 percent for 2000 and 2020, will be maintained basinwide for all waste discharges. In some cases it may be practical to provide higher levels of waste treatment for removal of residual organic material and nutrients.

Based on the above treatment levels and raw waste projections presented earlier, the projected municipal waste loadings to be discharged to waters are shown in table 44. The industrial waste loadings for major industrial categories are presented in table 45. The total municipal and industrial organic waste discharge is expected to be 517,200 PE in 1980, 545,900 PE in 2000, and 821,200 PE in 2020.

Table 44 - Projected Municipal Organic Waste Discharges, Subregion 2

	1980	2000	2020
		(1,000's P.E.)	
Tri-Cities Service Area	17.1	18.7	26.7
Other	19.2	17.6	22.8
Total Subregion	36.3	36.3	49.5

Treatment Costs

Curves showing estimated costs of constructing (total capital) and operating (annual operation and maintenance) municipal sewage treatment plants for various treatment levels are presented in the "Means to Satisfy Demands" section of the Regional Summary.

Table 45 - Projected Industrial Waste Discharge, Subregion 2

	1980	2000	2020
		(1,000's P.E.)	
Food Products			
Grant and Adams Counties	382.0	405.0	613.0
Chelan County	54.0	51.0	71.0
Okanogan County	13.5	12.5	18.0
Other	0.5	0.5	1.0
	450.0	469.0	703.0
Pulp and Paper			
Chelan County	30.0	40.0	68.0
Lumber and Wood Products			
Okanogan County	0.7	0.5	0.5
Chelan County	0.2	0.2	0.2
	0.9	0.7	0.7
Total	480.9	509.7	771.7

Other Pollution Control Practices

Some of the water quality problems of the Upper Columbia Subregion are beyond the reach of conventional treatment and flow regulation. Solutions to these problems are not as clear-cut but are just as important in maintaining water quality.

Irrigation return flows have a detrimental effect on the water quality within the Columbia Basin Project. The return flows show an increase in total solids, nutrients, coliform bacteria, and temperature as they accumulate and re-enter the stream system. In addition, the return flows have raised ground-water levels in some areas and have contributed to the deterioration in ground-water quality. In other areas, saline-alkali ground water has been improved by dilution. Because treatment of irrigation return flows is not feasible, other means of controlling quality are necessary. Research is currently being conducted to develop methods of applying irrigation water, fertilizers, and pesticides more effectively to improve the quality of the return flows.

Rural waste will be of major significance in the subregion. The disposal of rural waste to septic tanks and drainage fields will continue to represent a hazard to the ground-water aquifer. High ground-water levels create additional problems with the drainage fields.

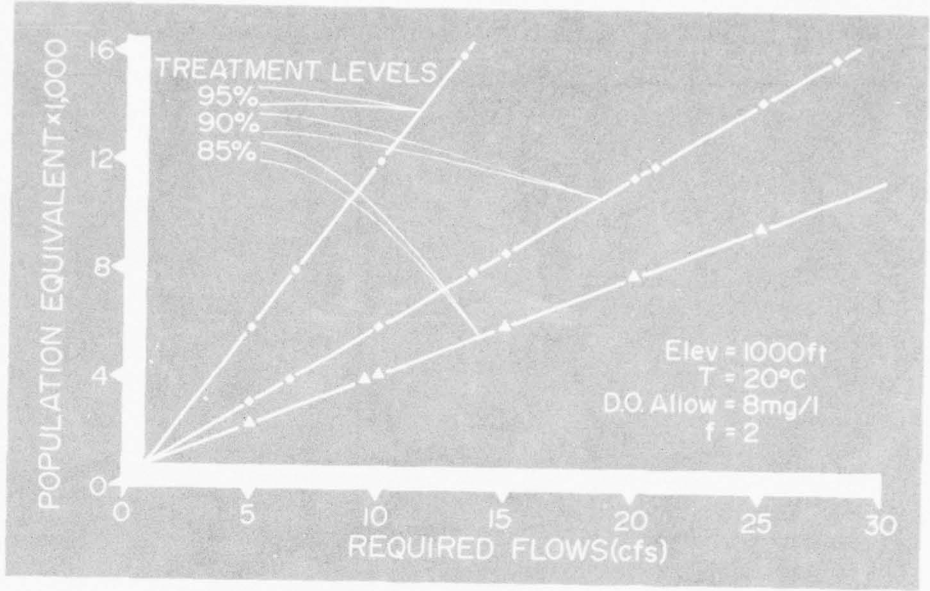


FIGURE 19. Minimum Flow Needs to Maintain Washington Dissolved Oxygen Standards Criteria (Elevation 1000 feet)

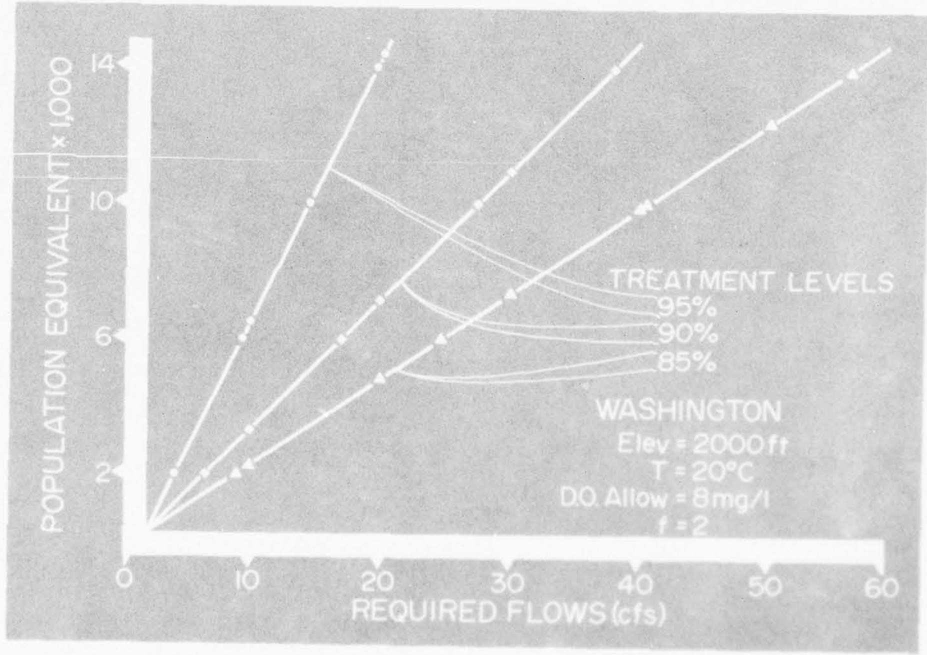
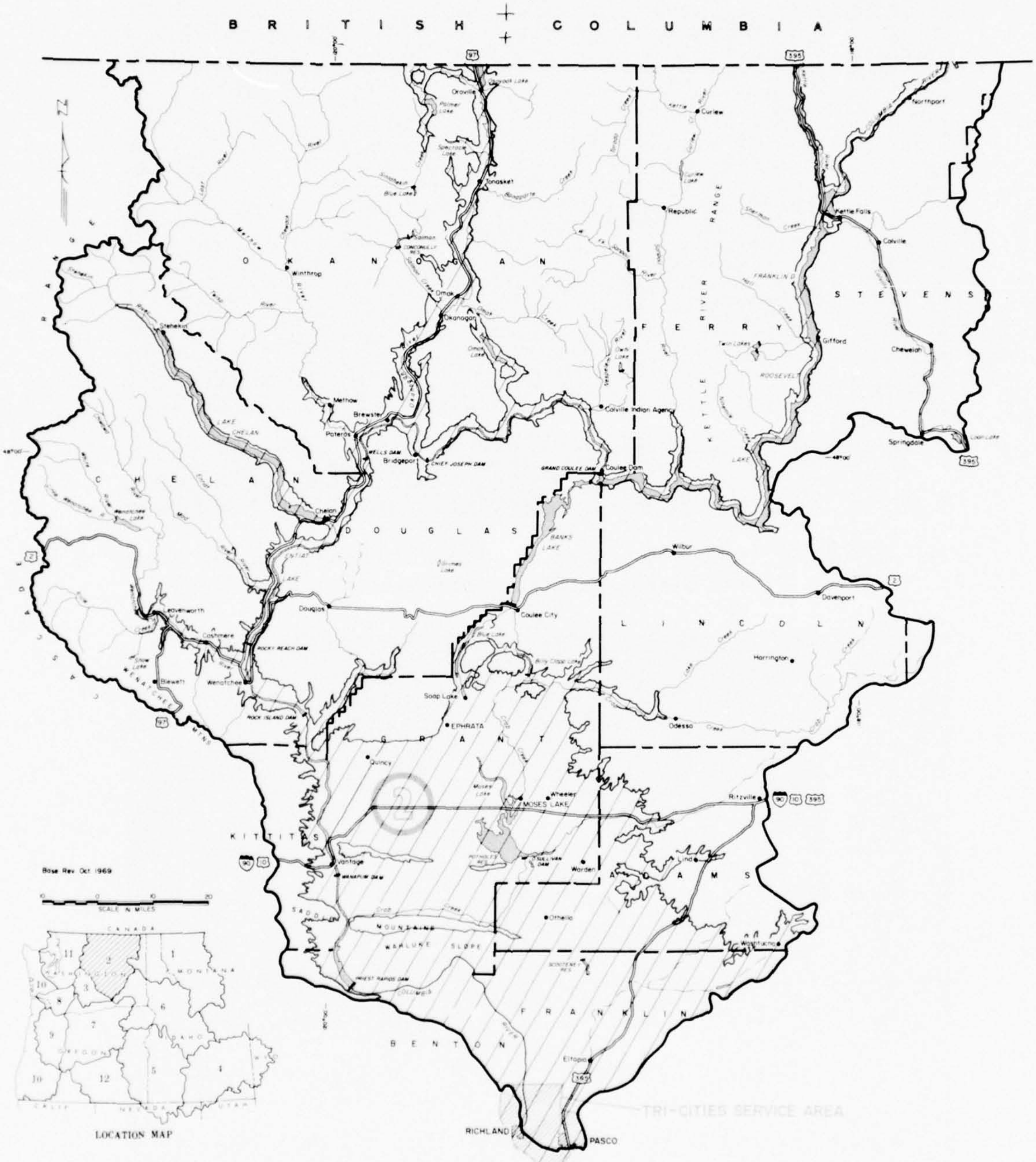


FIGURE 20. Minimum Flow Needs to Maintain Washington Dissolved Oxygen Standards Criteria (Elevation 2000 feet)



LEGEND

WASHINGTON — 1,500 FOOT CONTOUR LINE

AREA BELOW 1,500ft ELEVATION

COLUMBIA-NORTH PACIFIC
COMPREHENSIVE FRAMEWORK STUDY

AREAS TO WHICH FIGURES 19&20 APPLY

UPPER COLUMBIA SUBREGION 2

1970

FIGURE 21

The large animal population in the subregion represents the largest potential source of organic wastes; however, most of the waste production remains on the land and does not reach the waterways. This situation is changing; with the increased use of feedlots, the waste is more concentrated. Fences and simple retaining structures between the animal habitat and watercourses should be provided in order to prevent bank erosion and to limit direct surface drainage to the stream. The waste must be collected for treatment or for distribution to the land as a soil conditioner.

Recreation areas will be increasing in numbers, size, and intensity. Sewage disposal systems adequate to cope with weekend loads from use by thousands will be needed in many recreation areas. Facilities for collection and pickup of litter and garbage must also be made available, since these things may add to the waterborne debris load.

Thermal powerplants will be required to cool waste water before discharge into surface streams, and once-through cooling will no longer be permitted. Heavy metals and other inhibitors in the cooling water must not be discharged into streams or ground water.

Minimum Flow Requirements

Since waste treatment does not provide an economic solution for complete removal of contaminants from waste streams, and waste discharges from non-point sources, a certain amount of streamflow is necessary for dilution and assimilation of residual wastes. The minimum flow requirement is related to a number of factors, including the strength and deoxygenation capacity of the wastes; and the temperature, reaeration capacity, elevation, and minimum allowable dissolved oxygen for the stream.

A set of generalized curves showing minimum flow requirements for raw waste loadings subjected to various treatment levels is presented in figures 19 and 20 for several dissolved oxygen objectives, elevations, and self-purification factors (a combined characteristic of the waste and receiving stream). Figure 21 shows generalized areas for which particular curves are applicable. These figures give only approximate requirements for small and middle-sized communities with a normal mix of municipal and industrial wastes.

Tri-Cities Service Area The population of the Tri-Cities Service Area is projected to increase from 91,000 in 1965 to 213,500 in 2020. The major industrial waste material will continue to be near the outside limits of the service area. A

major nuclear fuels processing plant is being considered, and the Hanford Atomic Works is presently discharging into the Columbia River. The impact of the radioactive waste is not fully understood at this time. In addition, a 60,000-head-per-year feedlot and a 130,000-head-per-year meat packing plant are planned in the vicinity of the Tri-Cities Service Area. Means for controlling waste from feedlots are not completely developed at this time.

Other Minimum Flow Requirements

The pulp and paper industry and the wood products industry are expected to expand significantly in the Wenatchee area. The food products industry is projected to be the largest producer of organic waste. Nonoverflow lagoons or primary settling, followed by land application of the effluent by various methods of irrigation, eliminate the release to surface streams.

Management Practices

The state occupies a strategic position in water quality management. It is the focal point and has a major responsibility for water pollution control. The ability of the pertinent state agencies to discharge their responsibilities must be strengthened in order to enhance the effectiveness of their roles in water quality management. The capacity to control the water resources is an important factor in preserving water quality of the streams. While flows are generally adequate to assimilate waste discharged to the stream, both now and in the future, a dependable flow must be guaranteed.

Stronger land use controls and other associated controls must be developed: (1) that give significant attention to the physical capabilities of the waters, and (2) that give protection to the various uses of water. Conflicting uses of water will increase in future years along with the increase in water-use activities. In recreation activities alone, the water skier, the fisherman, and the swimmer conflict. Special recreation waters will have to be designated in order to keep such conflicts at a minimum. Restrictions of some activities will probably be required whenever they tend to "overuse" areas and degrade the water quality.

SUBREGION 3

LOCATION MAP

SUBREGION 3

YAKIMA

INTRODUCTION

The Yakima Subregion consists of the area drained by the Yakima River and lies entirely within the State of Washington. The total area is 6,062 square miles. The principal tributaries of the Yakima River drain the eastern slopes of the Cascade Range. About three-fourths of the subregion is in the Columbia Basin physiographic province. The remainder is in the Cascade Range.

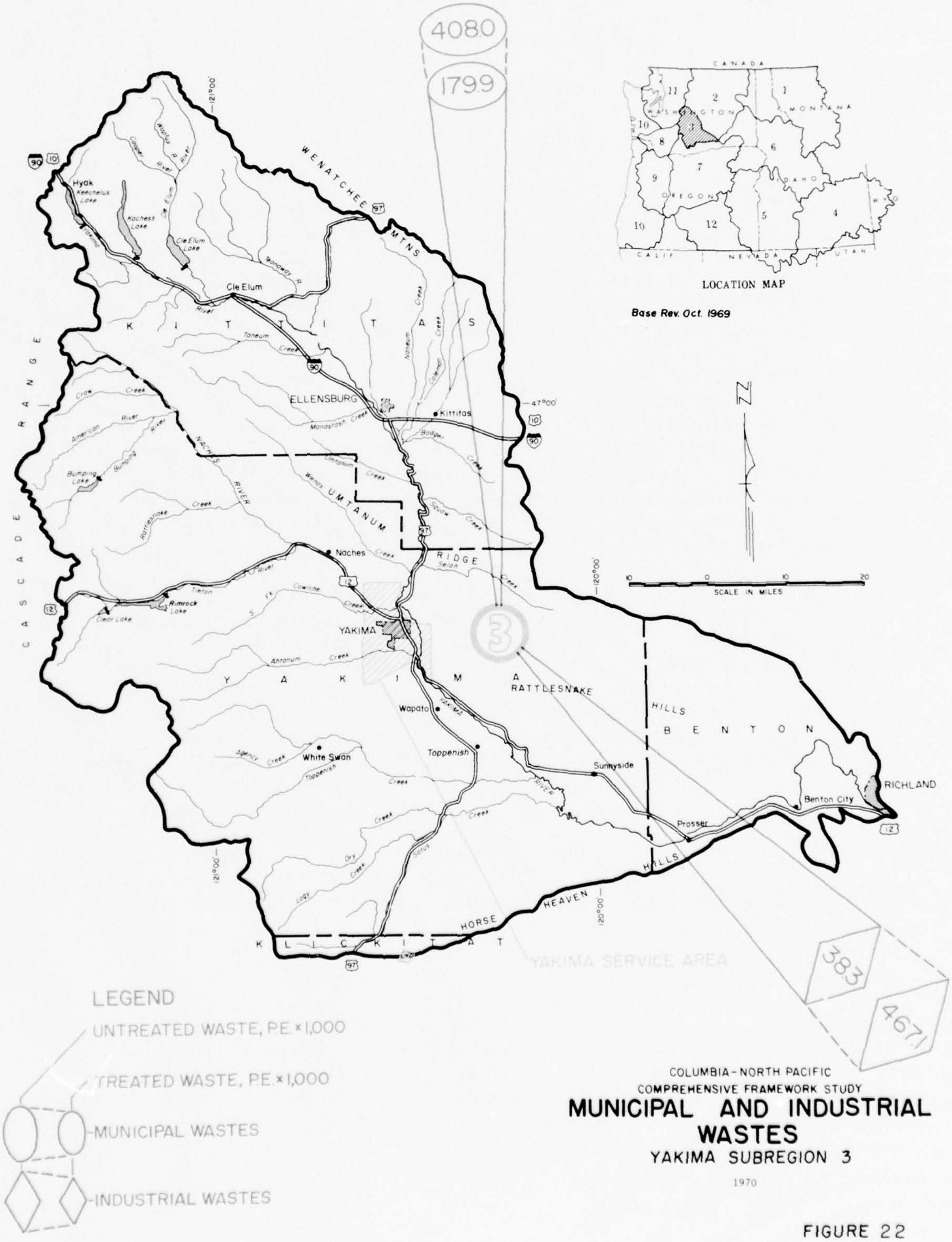
Like all of the area east of the Cascade Range, total precipitation is low and the temperature range is quite large. Record temperatures range from -25° to 110°F. (-32 to 43°C.). A frost-free season of from 160 to 200 days in the valleys is normal. About one-third of the subregion receives less than 10 inches of precipitation annually; the remaining area, from 10 to 30 inches; although in a small area of the Cascades more than 100 inches are consistently recorded.

Agriculture is the primary economic activity. Yakima is a center for processing of both fruit and vegetable crops grown in the adjacent valleys. There are a limited number of lumber and wood products plants.

In the valleys, population densities are high but in the surrounding rangelands are extremely low. The population in 1965 totaled about 184,500 and is centered in the towns along the Yakima River.

PRESENT STATUS

Sources of pollution in the Yakima Subregion are closely related to the economic base of agriculture. Municipalities and industries are the largest sources of organic wastes. The food-processing industry accounts for most of the industrial waste production and nearly three-fourths of the waste load discharged to municipal systems. A graphical summary of municipal and industrial organic waste production and discharge is presented in figure 22. Diversion of water to large irrigation developments tends to reduce the assimilative capacity of the Yakima River, and return flows significantly affect water quality. Extensive stock watering and feedlot activities also have an important impact on water quality.



COLUMBIA-NORTH PACIFIC
COMPREHENSIVE FRAMEWORK STUDY

MUNICIPAL AND INDUSTRIAL WASTES

YAKIMA SUBREGION 3

1970

FIGURE 22

The headwaters of the Yakima River and most tributaries are of adequate water quality for most purposes. However, during the period of low streamflow, the lower reaches of the Yakima River suffer from serious water quality degradation. The most significant problems are high stream temperatures, heavy algal growths, and bacterial contamination.

Stream Characteristics

The principal streams draining the east slope of the Cascade Range in the northern portion of the subregion are the Yakima, Kachess, and Cle Elum Rivers. Further south is the Naches River, whose main tributaries, Bumping and Tieton Rivers, also head in the east slope of the Cascade Range. Issuing from the foothills of the Cascade Range are the North and South Forks of Ahtanum Creek. All streams are fed largely by snowmelt from the Cascade Range.

The average annual runoff from the subregion amounts to about 3,240 cfs (2.35 million acre-feet). This results in a little more than one-half cubic foot per second per square mile.

Surface-Water Hydrology

The streamflow is strongly influenced by storage reservoirs and numerous irrigation diversions. The discharge pattern is characterized by maximum discharges between May and September in the headwater areas when storage releases are being made. These waters are largely diverted for irrigation in the middle and lower reaches of the Yakima. As a result, extremely low flows occur in the lower Yakima River between July and October. Table 46 presents monthly discharge data for selected stations.

From the standpoint of waste discharge control, the low-flow months from July to October are the most important. This is the peak canning period for the food-processing industry. The minimum flow in the Yakima River occurs near Parker, below the Sunnyside diversion and below the Prosser diversion dam. Return flows result in a substantial recovery, and the flow is increased between Parker and Kiona. One-in-ten-year low flow is the selected recurrence frequency designated to describe critical low flows. These data are summarized for selected stations in table 47.

Impoundments and Stream Regulation

Streamflow is regulated by six headwater reservoirs with a total capacity of more than one million acre-feet and numerous diversions for irrigation. Storage and regulation are provided to make irrigation water available in amounts and at times needed (April through October) with flood control operation and special fishery releases only to the extent that they do not interfere with irrigation. The operating schedule of the reservoirs consists of stopping releases from four of the reservoirs at the end of the irrigation season so that they may fill as rapidly as possible. A flow of 25 to 30 cfs is maintained in the Cle Elum River below the dam to meet water supply needs of the City of Cle Elum. Releases from storage may begin as early as April or as late as July, depending on runoff conditions.

All waters in the Yakima Subregion, except some surplus flows during winter months, are fully appropriated. If all water rights were exercised simultaneously during summer months, much of the water would be reused several times. With existing storage, all water rights can be met during normal water years. However, during dry years, storage is inadequate and the available water is prorated according to priorities established by adjudication. Records show that flows below some diversion points, particularly those below Sunnyside and Prosser, fall to less than 50 cfs for several days at a time. This has resulted in critical water quality problems.

Ground-Water Characteristics

The ground-water resources of the Yakima Subregion are an important complement to the surface-water resources of the area. With few exceptions, municipalities utilize ground water for supply purposes. In addition, it is used extensively for individual industrial and domestic purposes and irrigation.

There are three important aquifer units in the Yakima Subregion: the alluvium, the Ellensburg formation, and the basalt of the Columbia River group. Moderate to moderately large yields can be obtained from wells in any one of the three aquifer units at favorable locations, and there have been considerable development and utilization of ground water for each. The area of most intense ground-water use is in the Ahtanum Valley.

In general, ground-water quality is adequate for most purposes. In the alluvial aquifer unit, the dissolved solids are generally less than 300 mg/l; total hardness is 40 to 150 mg/l; fluoride and iron are low; and the water is a calcium-magnesium

Table 46 - Average Monthly Discharge, Subregion 3 (12)

Location	Jan.	Feb.	March	April	May (CFS)	June	JJuly	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
Yakima River near Martin Wn.	77	17	28	48		741	715	718	618	244	108	88	327
Kachess River near Easton, Wn.	38	46	27	46	302	479	667	907	692	107	48	71	286
Cle Elum River near Roslyn, Wn.	62	85	57	247	1,631	2,291	2,182	2,207	1,347	386	250	189	911
Yakima River at Cle Elum, Wn.	578	532	590	1,120	2,837	3,237	2,704	2,910	2,018	751	787	837	1,575
Yakima River at Umetanum, Wn.	1,107	1,184	1,618	2,857	4,446	4,187	2,958	3,184	2,384	1,191	1,358	1,430	2,325
Bumping River near Nile, Wn.	67	91	122	129	727	808	515	333	185	112	195	166	288
American River near Nile, Wn.	112	116	139	337	711	636	291	88	56	74	131	154	235
Tieton River at Tieton Dam near Naches	138	161	56	83	733	1,121	1,150	1,104	838	213	171	169	495
Naches River below Tieton River near Naches	696	782	843	1,826	3,934	3,482	1,942	1,222	802	481	758	969	1,478
N.F. Ahtanum River near Tampico, Wn.	30	36	51	121	201	161	56	25	18	20	25	35	65
S.F. Ahtanum River at Conrad Ranch near Tampico	11	14	19	34	48	40	15	8	7	7	8	12	19
Yakima River near Parker, Wn.	2,313	2,313	2,385	2,037	4,129	3,330	343	125	125	586	2,264	2,786	1,894
Yakima River at Kiona, Wn.	2,966	3,344	3,685	3,556	5,712	5,409	1,911	1,584	1,994	2,051	3,134	3,533	3,240

Table 47 - One-in-Ten-Year Low Flows, Subregion 3 (12)

Stream and Location	One-in-Ten-Year Low Flow 1/ (cfs)
Yakima River near Martin, Washington	< 1
Kachess River near Easton, Washington	<1
Cle Elum River near Roslyn, Washington	12
Yakima River at Cle Elum, Washington	110
Yakima River at Umatanum, Washington	300
Bumping River near Nile, Washington	<10
American River near Nile, Washington	24
Tieton River at Tieton Dam near Naches Washington	10
Naches River below Tieton River near Naches, Washington	180
North Fork Ahtanum Creek near Tampico, Wash.	9
South Fork Ahtanum Cr. at Conrad Ranch near Tampico, Washington	4
Yakima River near Parker, Washington	60
Yakima River at Kiona, Washington	1,000

1/ Period of 1 month.

bicarbonate type. The Ellensburg formation is characterized by dissolved solids of less than 300 mg/l, moderately hard to hard water, low fluoride and iron, and a calcium-magnesium bicarbonate water with small quantities of sulfate and chloride. In the Columbia River group, ground-water quality is generally characterized by dissolved solids of less than 250 mg/l; a total hardness of 50 to 100 mg/l; and a bicarbonate water, with calcium plus magnesium generally exceeding sodium. In a few wells, sodium is an objectionable concentration, with the sodium adsorption ratio (SAR) ranging to three.

Bacterial contamination of shallow wells in some suburbs of Yakima has been reported by the Yakima County Health Department.

Pollution Sources

The municipal and industrial waste loadings and discharges, in population equivalents, for the Yakima Subregion are summarized in table 48.

Table 48 - Summary of Municipal and Industrial Waste Treatment, Subregion 3[1/]

	Municipal					Industrial		
	Primary	Secondary	Lagoons	Other	Total	Food Processing	Lumber and Wood Products	Total
Number of facilities	3	17	5	3	28	28	2	30
Population served	10,480	80,130	6,250	1,200	98,060			
PE produced	131,880	257,030	17,850	1,200	407,960	466,040	1,100	467,140
PE discharged	103,330	71,500	3,840	1,200	179,870	37,525	800	38,325
% removal efficiency	22	72	79	0	56	92	73	92

1/ FWPCA inventory of Municipal and Industrial Wastes, Yakima Subregion, 1965.

During the summertime low streamflow periods, municipalities and industries produce wastes equivalent to those from a population of 875,100 persons. Of this total, 53 percent is generated by the food-processing industry and 46 percent by municipalities. Waste treatment and other means of waste reduction decrease the total organic load to the waterways by about 75 percent, so that 218,200 population equivalents actually reach the watercourses. Of this total, 179,870 PE are released by municipalities, and 38,325 PE are discharged by industries. However, the food-processing industry accounts for about 140,000 population equivalents that are discharged from municipal systems.

Irrigation diversions and return flows are also major pollution factors. Agricultural drainage from the animal population is also a major pollution source. Other sources of pollution include wastes from the rural-domestic population, land use, recreation, and natural sources.

Municipalities

The average reduction in biochemical oxygen demand is about 56 percent, resulting in an organic waste loading to waterways of about 179,900 PE. Of the 28 municipalities served by waste collection systems, 17 provide secondary waste treatment, five have lagoons, three provide primary waste treatment, and three employ other forms of waste treatment or no waste treatment.

Ten communities utilizing secondary waste treatment do not have final clarification units. The Washington Water Pollution Control Commission requires that these communities provide such units or at least the level of treatment achieved by conventional secondary treatment. The three communities having primary waste treatment should upgrade to secondary treatment, or the equivalent, within the next 5 years. In addition, several small communities having no waste treatment facilities should also install secondary treatment or the equivalent. Generally, communities operating lagoons accomplish an adequate level of waste treatment.

The major population center is the Yakima Service Area, which includes the cities of Yakima, Selah, and Union Gap. Approximately 78 percent of the service area population, or 61,580 persons, are served by municipal waste collection and treatment systems. In addition, all municipal systems receive wastes from several food-processing industries. In general, an excellent level of waste treatment is practiced, so that only about 14,600 PE are released to waterways from the service area. Only the Yakima Housing Authority is in need of improved treatment, and has been requested to upgrade its primary treatment facilities to secondary treatment or the equivalent.

The Ellensburg area is a major waste source. The City of Ellensburg presently has a primary waste treatment plant that is overloaded from July to September by wastes from a food processing plant. During this period, approximately 102,000 PE are discharged from the facility to Wilson Creek, a small tributary of the Yakima River. The community is now expanding its present facilities to handle industrial waste loadings and is upgrading to secondary waste treatment.

The communities of Easton, Roslyn, South Cle Elum, and Cle Elum along the upper reaches of the Yakima River are also important municipal waste sources. These municipalities release raw sewage from a population of about 2,300 persons. Only Cle Elum provides any type of waste treatment; however, 50 percent of its raw sewage bypasses the treatment facilities and is discharged to the Yakima River. Secondary treatment or the equivalent should be provided at Easton, South Cle Elum, and Roslyn; Cle Elum should expand its facilities to adequately treat present waste loadings.

The City of Prosser recently completed an enlargement of its secondary treatment plant to handle food-processing wastes from a packing plant; however, increased production by the packers has overloaded the facility. The industry operates from April through February and produces organic wastes equivalent to those from a population of 120,000 persons. The combined municipal and industrial secondary waste treatment facility discharges an organic loading of about 50,000 PE during the canning period.

The only other municipalities discharging significant organic waste loadings are Toppenish, Wapato, Sunnyside, and Grandview. These communities, as well as most of the remaining communities, have secondary waste treatment or lagoons. Only the small community of Harrah with primary facilities and those communities that have secondary treatment plants without final clarification units provide less than adequate treatment.

Industries

Industrial waste production in the Yakima Subregion is mostly the result of food-processing activities and is highly variable, depending on the season. The peak industrial waste production is about 770,000 PE in the month of September. The average industrial waste production is about 390,000 PE.

During the period of maximum waste production, about 300,000 PE of organic food-processing wastes are discharged to municipal waste treatment systems. These waste sources are discussed in the section on municipal pollution sources. For the remaining 470,000 PE, waste treatment consists primarily of spray irrigation and non-overflow lagoons, with about 38,325 PE of organic wastes reaching the watercourse.

The Yakima Service Area is the major source of industrial waste production. During the peak period for food processing, about 316,000 PE of organic wastes are generated within the service area. About 226,000 PE are discharged to the City of

Yakima's industrial sewer, which are disposed of by spray irrigation, allowing little direct discharge of wastes to the streams. A fruit growers plant operates an aerated lagoon. During the peak period from June to October, about 25,000 PE are released to the Yakima River from this facility.

The Wapato-Toppenish area is also a major industrial waste production center. About 120,000 PE of organic food-processing wastes are generated and must be treated by industries in this area. Treatment practices are generally satisfactory, allowing only about 8,650 PE to be discharged to waterways during the canning period. The largest single waste source produces approximately 70,000 PE from April to October. The waste water is used for crop irrigation, resulting in little direct discharge to the streams. A fruit products plant also practices crop irrigation with its untreated waste waters. A food processing company at Zillah discharges about 6,000 PE to the Yakima River and has been requested to install primary treatment and to upgrade its lagoon treatment. A sugar company at Zillah has a sludge lagoon for removal of solids and uses excellent in-plant reuse methods to limit effluent strength to about 1,000 PE. A packing company at Toppenish is the only other industry in the area discharging a significant waste loading. The plant releases about 1,650 PE from its treatment lagoons.

The Ellensburg and Sunnyside areas are the only other significant industrial waste production centers in which the industries treat their own wastes. Industries in the Prosser and Grandview areas generate large quantities of wastes, but they are treated by municipal facilities and are considered in the municipal pollution sources section. In the Ellensburg area, three packing companies operate non-overflow lagoons. Lagoon treatment is also practiced in the Sunnyside area by a winery and by a rendering company. These industries discharge 900 and 75 PE, respectively, to Sulphur Creek.

Wastes from wood and lumber products industries are relatively minor. Lumber mills at Naches and Yakima contribute 500 and 300 PE to waterways. Log ponds and screening are utilized for treatment.

Rural-Domestic

Approximately 86,440 persons, or 47 percent of the subregion's population, are served by individual waste disposal systems. In general, septic tanks and some type of subsurface disposal are used by the rural population. The actual waste load reaching waterways is not considered to be large.

Irrigation

The most significant water use in the Yakima Subregion is irrigation. The total area for which water is diverted is about 505,000 acres. Diversion rates per acre average about 4.9 acre-feet per year, or a total volume of about 2.5 million acre-feet per year. Irrigation return flows from the upper basin are reused to irrigate portions of the lower basin.

The major irrigation diversion canals in the Yakima Subregion include the Kittitas, Roza, Tieton, Wapato, Sunnyside, and Kennewick Canals. Substantial flows are maintained in the Yakima River down to the Wapato and Sunnyside Canals, a few miles below Yakima. Most of the late summer flow is comprised of storage releases from headwater reservoirs. During August and September, flow in the Yakima River drops drastically below the Sunnyside and Wapato diversions, picking up again further downstream as drains gradually return irrigation water. Practically all existing water rights below these diversions are for irrigation, and appropriations are up to five times the mean flow of the stream. Low flows in the river result in an increased water temperature which may be detrimental to the fishery resources. In addition, higher temperatures increase algal productivity resulting in an aesthetically undesirable condition.

The chemical, physical, and biological quality of irrigation return flows in the Yakima Subregion has been studied by Sylvester (15), the Public Health Service (18), and the Washington Water Pollution Control Commission. Data obtained in these studies show that turbidity, BOD, dissolved solids, coliform organisms, and temperature are somewhat higher in irrigation drains than in the river. Pesticides and other agricultural chemicals have also been found in return drains. Sufficient data on which to evaluate deleterious effects of pesticides, however, are not available. The following conclusion was reached by Sylvester concerning irrigation return flow in the Yakima River: Irrigation return flows were the major factor influencing the overall water quality of the Yakima River as compared with domestic sewage and industrial waste discharges; however, the water quality of the lower Yakima River has not been seriously impaired by irrigation return flows, with the exception of increased water temperature and its relation to the fishery.

Agricultural Animals

Agricultural animal wastes are an important source of pollution in the Yakima Subregion. Large populations of animals--cattle, hogs, and poultry--produce an estimated organic waste equivalent to that from a population of 1.9 million persons. An

estimated 95 percent of the waste is reduced by soil action and natural decomposition so that about 95,000 PE reach waterways. The Washington Water Pollution Control Commission is aware of this problem and is, at present, requiring that all feedlots be moved away from stream areas so that disposal may be made to land. Dairies, hog sheds, and poultry houses are also required to provide improved disposal techniques.

Other Land Use

Although little data are available, land use and management practices are generally considered to be satisfactory. The production and transport of sediment, which is generally the most significant quality impairment resulting from land use, are usually very low. Generalized sediment yields range between 0.02 and 0.5 acre-foot per square mile per year, but about 95 percent of the entire subregion produces less than 0.1. The generally low sediment yield may be attributable to either low precipitation and runoff or to good ground cover conditions where precipitation is high.

Present Water Quality

The water quality of the Yakima Subregion is monitored by a National Water Quality Network Station near the mouth of the Yakima River, and by Washington Water Pollution Control Commission Basic Data Stations, in cooperation with the Geological Survey at Cle Elum, Roza Dam, Parker, and Kiona on the Yakima River, near Naches and Yakima on the Naches River, at Oak Creek on the Tieton River, near Cle Elum on the Teanaway River, and at Thrall on Wilson Creek. Several agencies have also collected water quality data in the Yakima Subregion for short-term surveys. Table 49 summarizes annual mean and extreme values for selected water quality parameters where sufficient data are available.

Water quality in the upper reaches of the Yakima River system is very good. Surface water is generated mainly from snowmelt, and there is very little development in the area. The uppermost point of the river system receiving wastes is at Ronald on the Cle Elum River. From this point downstream to the mouth, the Yakima River and its tributaries receive discharges of municipal and industrial wastes, as well as drainage from irrigated agricultural areas.

Main Stem Yakima River

Dissolved oxygen concentrations in the Yakima River are normally maintained at satisfactory levels. Data collected during the summer of 1961 and shown in figure 23, indicate that the dissolved oxygen pattern in the main stem Yakima River is governed by photosynthetic organisms, and considerable diurnal fluctuation occurs. Minimum (nighttime) dissolved oxygen levels above Ellensburg range from approximately 7.5 to 9.0 mg/l during the critical summer months. These values correspond to 75 to 95 percent of saturation at prevailing temperatures. The minimum dissolved oxygen levels drop just below the point where Wilson Creek discharges to the Yakima River and recovers to a level approaching that above Ellensburg at Selah Gap. Below the Yakima Service Area, another dissolved oxygen depression occurs, which approaches a minimum of about 6.0 or 6.5 mg/l at Granger. Below Granger, the dissolved oxygen concentration recovers to a level at which minimum values are again in the range of 8 to 9 mg/l. Daytime dissolved oxygen levels remain high throughout the main stem Yakima River.

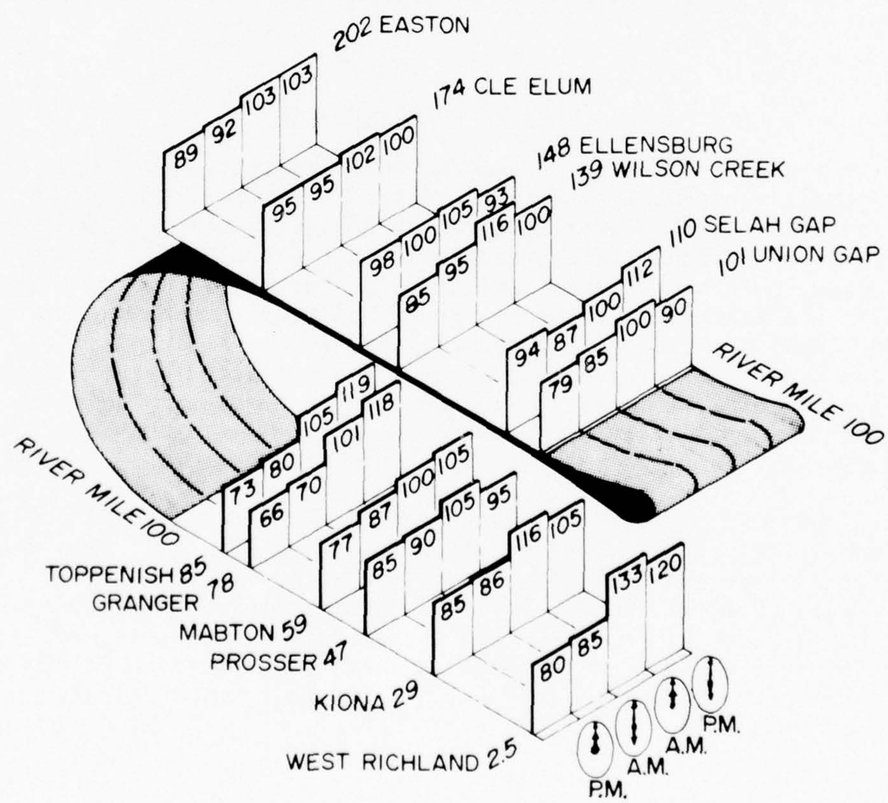


FIGURE 23. Dissolved Oxygen, Percent of Saturation, Yakima River

Table 49 - Summary of Water Quality Data, Subregion 3 1/

	River Mile	D.O. (mg/1)	T (°C)	Coliform MPN/ 100 ml	pH	Color PT-CO Units	Hard. (mg/1)	Turb. (JTU)	TDS (mg/1)	Ortho PO_4 (mg/1)	NO_3-N (mg/1)
Main Stem Yakima River											
Yakima River at Cle Elum, Wn.	183.1										
Mean		11.0	8.9	478	7.3	3	24	1	37	0.01	0.03
Min.		8.7	1.0	0	6.8	0	18	0	26	0.00	0.00
Max.		13.5	18.5	9,300	7.9	5	36	5	55	0.12	0.25
Yakima River at Roza Dam											
Mean		9.6	16.7	1,615	7.2	--	--	--	--	0.06	0.18
Min.		8.2	15.2	930	6.3	--	--	--	--	0.05	0.14
Max.		11.8	18.0	2,300	7.8	--	--	--	--	0.06	0.22
Yakima River at Union Gap, Wash.											
Mean		9.0	16.7	60,392	7.6	--	51	--	--	0.15	0.96
Min.		7.6	1.0	230	6.4	--	49	--	--	0.06	0.15
Max.		13.6	21.6	460,000	8.6	--	54	--	--	0.44	4.78
Yakima River at Kiona, Wn.											
Mean		10.6	15.8	5,995	8.1	13	128	10	--	0.07	0.80
Min.		8.2	2.5	100	7.4	5	52	1	--	0.01	0.18
Max.		14.3	26.5	20,000	8.9	22	278	60	--	0.10	1.38
Yakima River at Richland, Wn.											
Mean		--	--	--	--	--	--	--	--	0.05	0.34
Min.		7.3	0	5	7.2	0	44	0.5	--	0.03	0.17
Max.		15.8	27.7	15,000	9.1	30	190	245	--	0.08	0.69
Tributaries											
Naches River near Naches, Wn.	116.3-17.6										
Mean		11.8	7.9	107	7.3	5	24	4	49	0.03	0.03
Min.		8.9	0.4	0	7.0	0	16	0	31	0.00	0.00
Max.		14.5	19.3	930	7.7	20	36	20	71	0.08	0.09
Naches River near Yakima, Wn.	116.3-0.1										
Mean		11.9	9.6	394	7.5	5	30	6	60	0.05	0.05
Min.		8.5	0.0	0	6.3	0	19	0	37	0.00	0.00
Max.		16.6	22.8	4,600	8.8	15	48	20	87	0.10	0.20
Tieton River at Oak Creek, Wn.	116.3-17.5-1.6										
Mean		11.3	8.5	74	7.4	7	31	15	62	0.05	0.05
Min.		8.5	0.3	0	7.1	0	22	5	44	0.00	0.00
Max.		14.0	19.0	430	7.9	25	43	120	88	0.25	0.11
Wilson Creek at Thrall, Wn.	147.0-0.4										
Mean		10.0	7.6	2,346	7.5	6	136	--	221	--	0.77
Min.		8.9	4.1	230	7.3	5	86	--	143	--	0.34
Max.		11.7	12.9	11,000	7.8	10	158	--	260	--	1.38
Teanaway River near Cle Elum, Wn.	176.1-0.1										
Mean		11.3	8.5	1,922	7.7	5	61	7	80	0.02	0.07
Min.		8.5	0.5	0	7.2	0	42	0	58	0.00	0.00
Max.		15.1	21.0	23,000	8.6	15	94	60	119	0.07	0.27

1/ FWPCA Storet, 1968.

Saturation values of over 100 percent are generally maintained, and values of over 150 percent of saturation have been observed during periods of intense algal blooms.

Organic matter, in terms of biochemical oxygen demand (BOD), varies from less than 1 mg/l in the upper reaches to an average of about 3 mg/l below Union Gap.

A generalized profile of the bacterial quality of the Yakima River is presented in figure 24. Above Ellensburg, coliform densities are low, with the exception of localized problems in the vicinity of Roslyn and Cle Elum. Below Ellensburg, to the mouth of the Yakima River, bacterial densities are generally above 1,000 organisms/100 ml, indicating a condition unsuitable for swimming or for a raw water supply for municipal and food-processing purposes. The condition may have improved recently since the Washington Water Pollution Control Commission requires chlorination of all municipal effluents; however, runoff from irrigated areas and from livestock feeding and grazing areas is partially responsible for the high coliform densities.

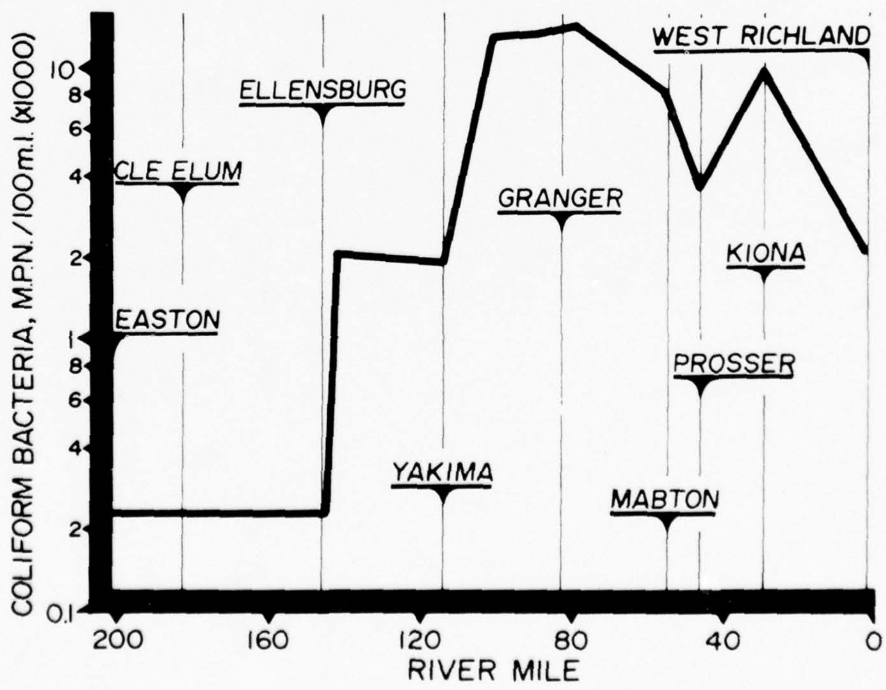


FIGURE 24. Coliform Bacteria Profile, Yakima River (August).

Large releases of cool water from storage, combined with inflow from the principal unregulated tributaries, result in relatively low summer temperatures in the upper Yakima River downstream to Parker. Average values are usually less than 60°F. (16°C.). Between Parker and Kiona, water temperatures rise rapidly to attain values of 70° to 80°F. (21° to 27°C.). Temperatures below Kiona remain essentially unchanged to the river mouth. Water temperatures at Kiona rise rapidly even with relatively high discharges (300 to 3,000 cfs). Figure 25 presents a generalized water temperature profile for the month of August.

The average nitrate concentrations in the river increase from approximately 0.1 mg/l (as N) in the Easton-Cle Elum area to approximately 0.2 mg/l in the Yakima area. The average concentration at Kiona is about 0.4 mg/l. The maximum concentration observed at Kiona is about 2.5 mg/l. Orthophosphate concentrations range from 0.001 or 0.002 mg/l (as PO_4) in the Easton area to 0.05 to 0.10 mg/l in the Yakima area. In the reach of the river between Zillah and Mabton, the phosphate concentration during the irrigation season increases rapidly to a level of 0.20 to 0.25 mg/l; and then remains fairly constant at that level to the mouth of the river.

Heavy growths of plankton and higher forms of aquatic growths are found in the Yakima River from Wilson Creek to the mouth. The photosynthesis and respirational activities of these organisms cause a wide diurnal fluctuation in several water quality parameters including dissolved oxygen, pH, and alkalinity.

The headwaters of the Yakima River originate in the Cascade Range, where precipitation exceeds 100 inches annually and the rock formations are highly resistant to solution. This environment produces a soft calcium bicarbonate water which has an average dissolved solids concentration of about 40 mg/l or less. After leaving the mountains, the Yakima River flows most of its length through an arid basin where precipitation averages less than 10 inches per year. Daily records since 1952 for the Yakima River at Kiona show the average annual dissolved solids concentration to be 169 mg/l. The maximum and minimum reported dissolved solids concentrations are 242 and 76 mg/l. The water at Kiona is still primarily calcium bicarbonate, but the percentages of sulfate and sodium are about twice those found in the headwater streams. Even though the mineralization increases over fourfold between the headwaters and the mouth, the waters of the Yakima River are still relatively low in dissolved solids and are only moderately hard. The water is in the low salinity class and is suitable for reuse as irrigation water.

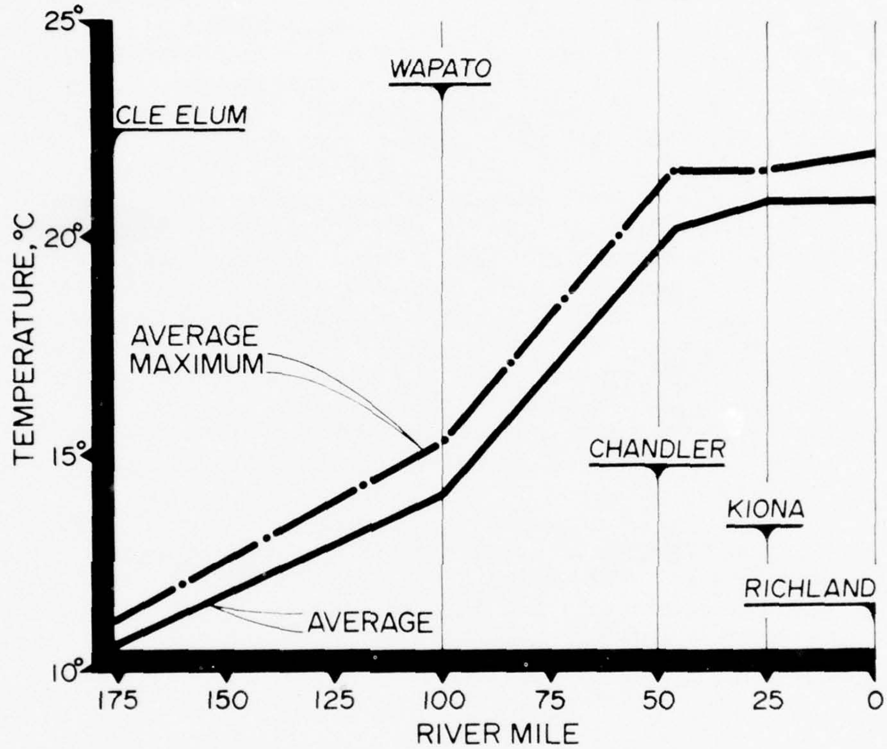


FIGURE 25. Water Temperature Profile, Yakima River (August).

Color and turbidity sometimes exceed the standards set for drinking water, and treatment would be required for control of these parameters. Incomplete data for the Yakima show that color increases from an average of about five units at Cle Elum to an average of 15 to 20 units in the lower reaches of the river. A maximum of 40 units has been reported at Enterprise. The Drinking Water Standards recommend that turbidity in the finished water should not exceed five JTU. Turbidity values in the Yakima averaged approximately two to five JTU in the Cle Elum area and 10 to 20 JTU in the lower reaches of the river, where a maximum of 110 JTU has been recorded. Values somewhat higher may occur during periods of high runoff.

Suspended sediment data for the Yakima Subregion are almost nonexistent. In several scattered studies, no concentrations higher than 84 mg/l were observed.

The National Water Quality Network Station near the mouth of the Yakima River has detected DDD, DDE, DDT, and Dieldrin in river waters. The station has not been in operation long enough to ascertain the significance of these pesticide materials.

Tributaries

The major tributaries in the Yakima Subregion are the Kachess, Cle Elum, Bumping, American, Tieton, and Naches Rivers; and North Fork Ahtanum Creek, South Fork Ahtanum Creek, and Wilson Creek. In general, these streams are of excellent mineral and physical character.

The tributaries are usually swift flowing and well aerated. Available data indicate that the mean dissolved oxygen level for all tributaries is above 10.0 mg/l. The minimum value observed has been 8.5 mg/l.

Wilson Creek and Teanaway River are the only major tributaries that show average coliform densities above the limit for safe water-contact recreation (1,000 organisms/100 ml). The maximum bacterial counts recorded have been 11,000 organisms/100 ml in Wilson Creek and 23,000 organisms/100 ml in the Teanaway River. Many irrigation return drains to the Yakima River are considered to have high bacterial counts, and studies have shown higher coliform densities in return flows than those observed in the applied water. (15) This was probably caused by the drainage of livestock wastes.

The tributaries of the Yakima River are generally a very soft calcium bicarbonate type water with a low dissolved solids concentration. Wilson Creek is the only stream with a dissolved solids concentration above 100 mg/l.

The streams usually have low levels of nutrients (phosphate and nitrate) and trace elements. As a result, most streams do not suffer from heavy aquatic growths which burden the lower Yakima River. However, Wilson Creek has an average nitrate concentration of 0.77 mg/l (as N). No data are available concerning phosphate levels. The creek periodically exhibits heavy algal growths. The condition is probably promoted by the discharge of domestic and food-processing wastes in the Ellensburg area.

No suspended sediment data are available for tributaries of the Yakima River. However, the low sediment yields which characterize the area indicate that the streams generally carry light sediment loads.

Summary of Problems

A graphical summary of water quality problem areas in the Yakima Subregion is presented in figure 26.

Low summer flows in the lower reaches of the Yakima River are detrimental to fish passage, both from a quantity standpoint and from a quality standpoint. The low flows, particularly below the Sunnyside and Prosser diversions, affect water quality and temperature.

High nutrient concentrations stimulate excessive growths of nuisance aquatic blooms from Wilson Creek to the mouth of the river.

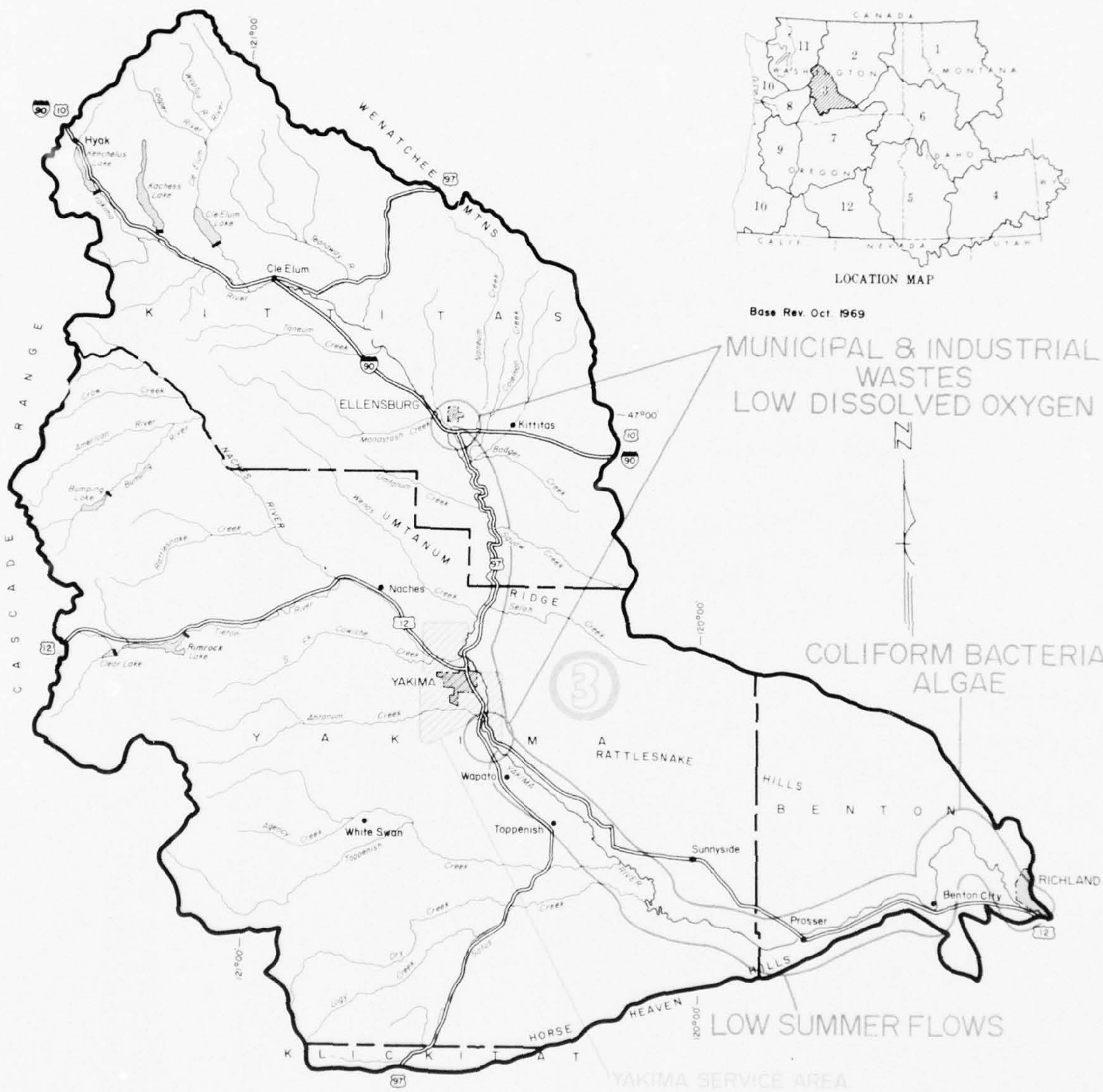
Coliform densities greater than the limit for safe water-contact recreation exist in the Yakima River from Ellensburg to the mouth. This condition results from inadequately chlorinated municipal wastes, irrigation return flows, and from agricultural drainages.

The State of Washington has been actively working to correct the bacterial problem in the middle and lower river. In addition, because of the low flows in the Yakima River, the state is requiring all communities and industries to reduce wastes to at least the level achieved by conventional secondary treatment. The state also has a program to reduce wastes from agricultural drainage.

FUTURE WATER QUALITY MANAGEMENT NEEDS

Based on the projected economic development of the Yakima Subregion, the population is expected to increase from 184,500 in 1965 to 327,000 in 2020. This is an increase of 77 percent for the subregion, compared with 121 percent for the region.

Figure 27 shows the projected subbasin population for the years 1980, 2000, and 2020. The projected service area populations for municipal and rural categories are presented in table 50. By 2020, nearly two-thirds of the subregion's population is expected to be located in the Yakima Service Area.



COLUMBIA-NORTH PACIFIC
COMPREHENSIVE FRAMEWORK STUDY

MAJOR WATER QUALITY PROBLEM AREAS

YAKIMA SUBREGION 3

1970

FIGURE 26

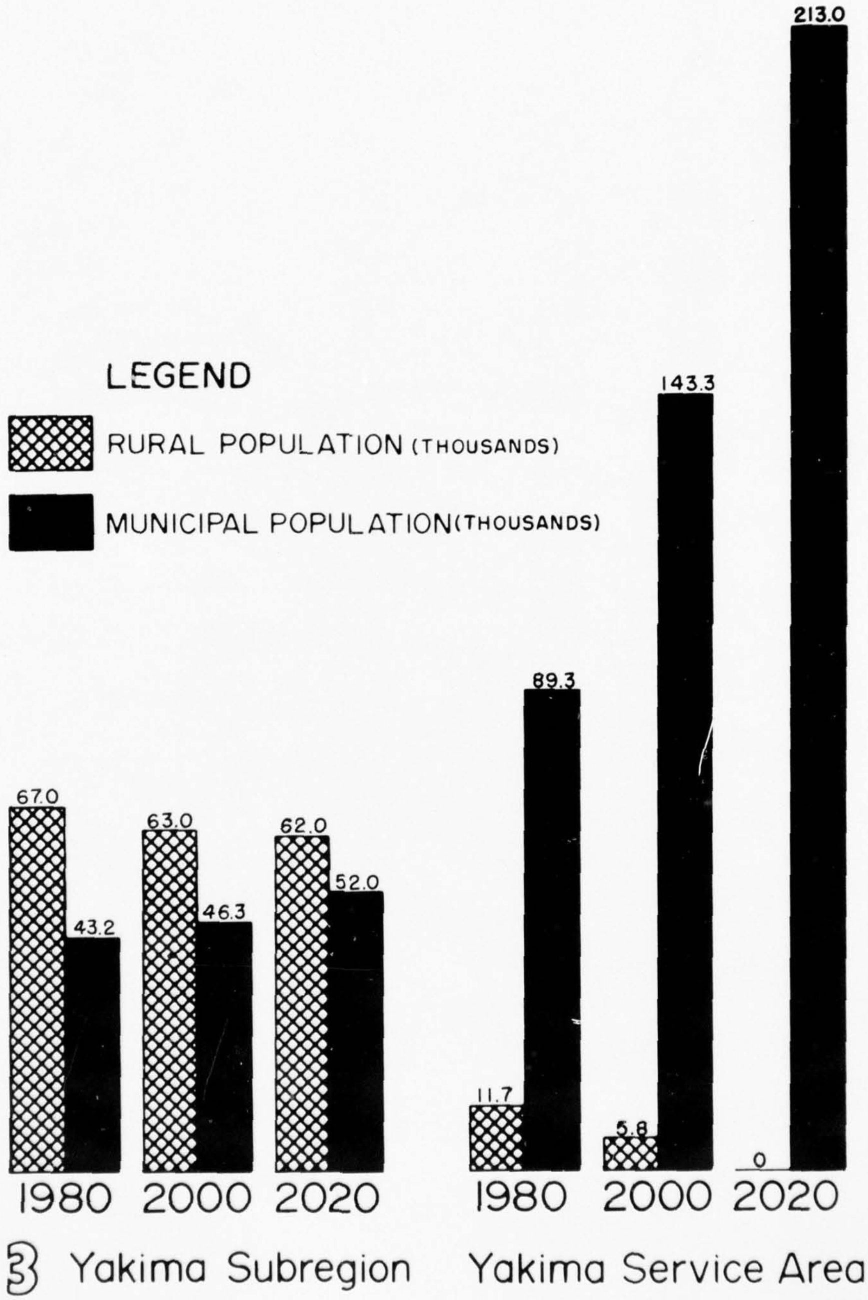


FIGURE 27. Projected Population, Subregion 3

Table 50 - Projected Population. Subregion 3 1/

	1980	2000 (thousands)	2020
Yakima Service Area	101.0	149.1	213.0
Municipal	89.3	143.3	213.0
Rural	11.7	5.8	-
Other	110.2	109.3	114.0
Municipal	43.2	46.3	52.0
Rural	67.0	63.0	62.0
Total Subregion	211.2	258.4	327.0
Municipal	132.5	189.6	265.0
Rural	78.7	68.8	62.0

1/ Derived from Economic Base and Projections, Appendix VII, Columbia-North Pacific Framework Study, January 1971 and from North Pacific Division Corps of Engineers Data. Differences between totals in this table and source are due to differences in subregion boundaries. The source is based on economic boundaries and this table is based on hydrologic boundaries. The municipal population is defined as that population discharging wastes to a municipal sewerage system. The rural population is defined as the residual.

Industrial development will continue to be based on agricultural, food-processing, and associated industries. The food products industry is expected to double as more lands are irrigated. The lumber and wood products industry is not expected to increase significantly.

Future Waste Production

Municipal

The projected municipal raw waste production for the Yakima Subregion is presented in table 51. The population served by municipal waste collection and treatment systems is expected to increase from 53 percent in 1967 to 81 percent by the year 2020. It has been assumed that the entire population in the service area will be served by municipal systems at that time.

Table 51 - Projected Municipal Raw Organic Waste Production, Subregion 3 1/

	1970	1980	2000	2020
		(1,000's P.E.)		
Yakima Service Area	92.4	111.6	179.1	266.2
Other	44.6	54.0	57.9	65.1
Total Subregion	137.0	165.6	237.0	331.3

1/ A factor of 1.25 was applied to the municipal population components to account for the effects of small commercial establishments and other urban activities which add to municipal waste loads.

The Yakima Service Area is expected to produce 80 percent of the subregion's municipal waste production, as compared with 67 percent at the present time.

Industrial

Projected raw organic waste *production for the major* industrial categories are presented in table 52 for the years 1980, 2000, and 2020. The food products industry will continue to be the largest organic waste source, contributing approximately 99 percent of the industrial waste production.

Table 52 - Projected Industrial Raw Organic Waste Production, Subregion 3 1/ (5) (17)

	1970	1980	2000	2020
		(1,000's P.E.)		
Food Products				
Kittitas County	55	125	180	240
Yakima County	440	932	1,350	1,990
Yakima Service Area	228	482	690	1,040
Other (downstream from Yakima)	212	450	660	950
Benton County	57	143	200	270
TOTAL	552	1,200	1,730	2,500
Lumber and Wood Products				
Yakima Service Area	1.2	1.5	1.9	2.1
TOTAL	553.2	1,201.5	1,731.9	2,502.1

1/ Base data from FWPCA Inventory of Municipal and Industrial Wastes, Yakima Subregion, 1965.

In general, increases in waste production are expected to occur at existing operations for most industries.

Rural-Domestic

The projected rural-domestic waste production for the Yakima Subregion is summarized in table 53 for the years 1980, 2000, and 2020. The rural-domestic waste production was assumed to be equal to the rural population component shown in table 51. The rural waste production is expected to remain relatively stable.

Table 53 - Projected Rural Domestic Raw Organic Waste Production, Subregion 3

	1970 1/	1980	2000	2020
		(1,000's P.E.)		
Total Subregion	83.8	78.7	68.8	62.0

1/ Interpolated from 1965 data and 1980 projections.

Irrigation

About 505,000 acres are presently irrigated in the Yakima Subregion, requiring an annual diversion rate of 4.9 acre-feet per acre. Irrigated acreage is projected to increase to 550,000 acres by 1980; 570,000 acres by 2000; and 610,000 acres by 2020. More efficient use and application of water are expected to reduce the diversion rate to approximately 3 acre-feet per acre, which would decrease the actual diversion from 2.5 million acre-feet per year at present to 1.8 million acre-feet per year by 2020. However, irrigation developments will still need to be studied individually to evaluate the impact on water quality.

The potential exists for detrimental effects to water quality from increases in silt, fertilizers, pesticides, salt, and temperature in excess or waste water from irrigated agricultural lands. In addition, irrigation also raises the natural ground-water table and results in ground water, with a salt content of approximately five times that of natural ground water.

Other Land Uses

Projections of land use in the subregion, by major types, are shown in table 54.

Table 54 - Present and Projected Land Use, Subregion 3 (5) (8)

	1966	1980	2000	2020
		(thousands of acres)		
Land Use				
Cropland	686	724	736	768
Irrigated	(490)	(536)	(552)	(590)
Nonirrigated	(196)	(188)	(184)	(178)
Forest	1,509	1,500	1,490	1,468
Range 1/	1,535	1,486	1,462	1,428
Other 2/	121	135	153	173
Total	3,851	3,845	3,841	3,837

1/ Does not include forest range.
2/ Includes barren land, roads, railroads, small water areas, urban and industrial areas, farmsteads, etc.

The projections show that croplands will increase by approximately 12 percent by the year 2020, whereas range and pasture show a 7 percent decrease for the same period.

The production and transport of sediment, which is generally the most significant quality impairment resulting from land use, are expected to increase proportionately to land use. Increased use of fertilizers on crop and pastureland will create a potential source of nutrients, which will continue to aggravate the algal problems. Pesticides applied to these lands can also have detrimental effects on the stream ecology.

Agricultural Animals

The raw organic waste production by the livestock population in the subregion is expected to be equivalent to that from a population of 3,400,000 in 1980; 4,500,000 in 2000; and 5,900,000 in 2020. This would account for approximately 66 percent of the total raw organic waste production for the subregion. Presently, most of the waste remains on the land and decomposes by natural processes. However, it is expected that a larger percentage of the cattle will be on feedlots by the year 2020, and less waste will be left on the land.

Animals concentrated in feedlots that are located along streams cause accelerated erosion as well as intensifying the potential for increase in coliform bacteria, nutrients, and biochemical oxygen demand in the water.

Recreation

As shown in table 55, wastes generated by recreational activity are projected to increase to 195,000 PE by 2020--more than 4 times present levels.

Table 55 - Projected Recreation Wastes, Subregion 3 1/

Year	Population Equivalents
1970	42,000
1980	57,500
2000	105,500
2020	195,000

1/ Bureau of Outdoor Recreation and U.S.D.A. Forest Service Projections for total man recreation days (TMRD).

In the determination of wastes from recreation activities, the population equivalent is based on the total annual recreation days. The values represent the daily raw waste production for a typical summer weekend.

Other Factors Influencing Quality

Although mining activities are at a low ebb, the Yakima Subregion contains the greatest number of copper mines in the state, and there is a potential for future discoveries and substantial future production of copper and silver. Mining wastes, if not adequately controlled, will have an adverse effect on water quality. Sand and gravel production is expected to remain consistently high and is also a threat to water quality if not controlled.

Quality Goals

Water quality standards were adopted by the State of Washington after holding public hearings. These standards are the basis for the water quality goals in this study.

The common parameters generally used are dissolved oxygen concentration, temperature, turbidity, and coliform density. The water quality standards are summarized in table 56.

Table 57, taken from the Washington Water Quality Standards, shows the water classification and use.

The uses and criteria given are not inclusive, and the Water Quality Standards should be consulted for specific information. A copy of the standards is available upon request from the Washington Water Pollution Control Commission.

MEANS TO SATISFY DEMANDS

Preserving water quality in the Yakima Subregion to adequately support the river system's functions will require a coordinated program of waste reduction, flow regulation, application of waste-controlling techniques, and development of a system of cooperative management of the subregion for pollution control. The achievement and preservation of good water quality are based upon people operating within the context of a political, social, and economic system. The attainment of adequate water quality will require an efficient, adequately staffed and funded water quality management system for attacking the water pollution problem.

Waste Treatment

Future Waste Discharges

Adequate waste collection and treatment facilities are the primary means for achieving water quality objectives in the Yakima Subregion. If additional requirements and actions become necessary to attain the desired quality levels, the standards and implementation plan will have to be revised accordingly.

For the purpose of this study, it is assumed that treatment efficiencies consisting of organic removal of 85 percent in 1980, and 90 percent in 2000 and 2020 will be maintained basinwide for all waste discharges. In some cases, it may be practical to provide higher degrees of waste treatment for removal of residual organic materials and nutrients.

Based on the above treatment levels and raw waste projections presented earlier, the projected municipal waste loadings to be discharged to the waters are shown in table 58. The largest industrial organic waste loads are from the food-processing industries during the late summer and fall months. Since a large portion of the waste is applied to the land and non-overflow lagoons, it is assumed that only 15 percent of the waste reaches the streams. The waste loadings presented in table 59 for major

Table 56 - Water Classification and Criteria (22), Subregion 3

Water Quality Standards	Class AA Extraordinary	Class A Excellent	Class B Good
Coliform	50 MPN	240 MPN	1,000 MPN
Dissolved oxygen	9.5 mg/1	8.0 mg/1	6.5 mg/1
Temperature 1/	60°F.	65°F.	70°F.
pH	6.5-8.5	6.5-8.5	6.5-8.5
Turbidity	5 JTU	5 JTU	10 JTU
Aesthetic values	Shall not be impaired by the presence of materials or their effects, excluding those of natural origin, which offend the sense of sight, smell, touch, or taste.		

1/ For all classes, the permissible increase in temperature over natural conditions is less than 1.8°F.

Table 57 - Water Classification and Use, Subregion 3 *(22)*

Legend

AA - Extraordinary
A - Excellent
B - Good
L - Light
M - Moderate
H - Heavy

Watercourse	Assigned Class (Tentative)	Present - Future	Commercial & Game Fish: Salmonid: Migration	Salmonid: Rearing	Salmonid: Spawning	Warm Water Fish: Rearing	Warm Water Fish: Spawning	Shellfish	Wildlife	Recreation: Water Contact	Recreation: Boating & Fishing	Recreation: Aesthetics	Water Supply: Domestic	Water Supply: Industrial	Water Supply: Agricultural	Electrical Power
Yakima River from headwaters to confluence of Cle Elum River	AA	P	H	H	H				H	L	H	H	L	L	H	
		F	H	H	H				H	M	H	H	M	H	H	
Yakima River from Cle Elum River to Wilson Creek	A	P	H	H	H				H	M	H	H	L	M	H	
		F	H	H	H				H	H	H	H	L	M	H	
Yakima River from Wilson Creek to Sunnyside Dam	A	P	H	H	L				H	L	H	M	L	M	H	L
		F	H	H	M				H	M	H	H	L	M	H	L
Yakima River from Sunnyside Dam bridge to confluence with Columbia River	B	P	H	H	H	M	M	M	M	L	H	L	L	L	H	L
		F	H	H	H	M	M	M	M	L	H	M	L	M	H	M
Cle Elum River from headwaters to Cle Elum Lake	AA	P	M	M	M				H	M	H	H	M	L	L	L
		F	M	M	M				H	H	H	H	M	L	M	L
Cle Elum River from Cle Elum Lake to confluence with Yakima River	A	P							H		L	H	L	L	M	
		F	M	M	M				H		M	H	M	L	M	
Naches River from headwaters to Snoqualmie National Forest boundary	AA	P	H	H	H				H	L	H	H	L	L	L	
		F	H	H	H				H	L	H	H	L	L	L	
Naches River from Snoqualmie National Forest boundary to confluence with Yakima River	A	P	H	M	M				H	L	H	H	H	H	M	L
		F	H	H	H				H	L	H	H	H	H	H	L
Bumping River from headwaters to confluence with Naches River	AA	P	M	M	M				H	L	H	H	L		M	
		F	H	H	H				H	L	H	H	M	L	H	
American River from headwaters to confluence with Bumping River	AA	P	H	H	H				H		H	H	L		L	
		F	H	H	H				H		H	H	M		L	
Tieton River from headwaters to confluence with Naches River	AA	P	L	M	L				H	L	H	H	L		H	
		F	M	M	M				H	M	H	H	M		H	

industrial categories assume 85 percent removal in 1980 and 90 percent removal in 2000 and 2020. The total municipal and industrial organic waste discharges are expected to be 205,000 PE in 1980; 196,900 PE in 2000; and 283,300 PE in 2020.

Table 58 - Projected Municipal Organic Waste Discharges, Subregion 3

	1980	2000	2020
		(1,000's P.E.)	
Yakima Service Area	16.7	17.9	26.6
Other	8.1	5.8	6.5
Total Subregion	24.8	23.7	33.1

Table 59 - Projected Industrial Organic Waste Discharges, Subregion 3

	1980	2000	2020
		(1,000's P.E.)	
Food Products			
Kittitas County	18.8	18.0	24.0
Yakima County	139.8	135.0	199.0
Yakima Service Area	(72.3)	(69.0)	(104.0)
Other (downstream)	(67.5)	(66.0)	(95.0)
Benton County	21.4	20.0	27.0
	180.0	173.0	250.0
Lumber and Wood Products			
Yakima Service Area	0.2	0.2	0.2
TOTAL	180.2	173.2	250.2

Treatment Costs

Curves showing estimated costs of constructing (total capital) and operating (annual operation and maintenance) municipal sewage treatment plants for various treatment levels are presented in the "Means to Satisfy Demands" section of the Regional Summary.

Other Pollution Control Practices

Irrigation return flows have a detrimental effect on the water quality of the Yakima River and its tributaries by increasing total solids, nutrients, coliform bacteria, and temperature. Because treatment of most irrigation return flows is not feasible,

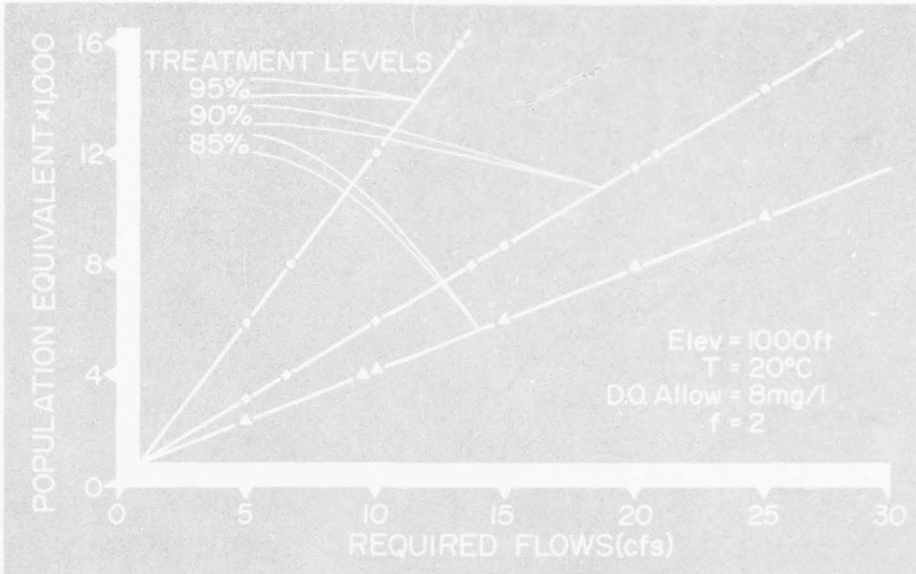


FIGURE 28. Minimum Flow Needs to Maintain Washington Dissolved Oxygen Standards Criteria (Elevation 1000 feet)

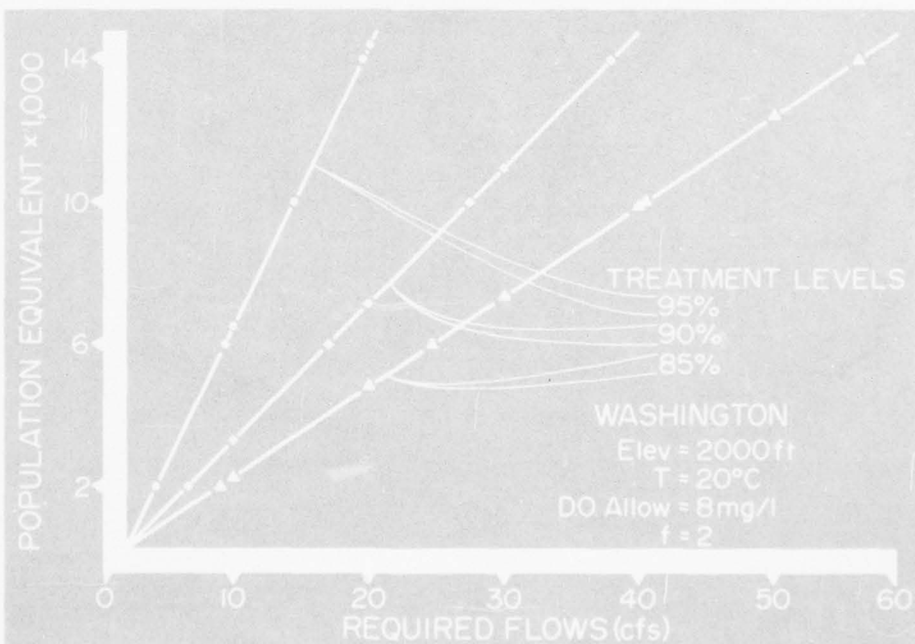


FIGURE 29. Minimum Flow Needs to Maintain Washington Dissolved Oxygen Standards Criteria (Elevation 2000 feet)

LEGEND

WASHINGTON

—1,500 FOOT CONTOUR LINE

AREA BELOW 1,500 ft. ELEVATION

COLUMBIA-NORTH PACIFIC
COMPREHENSIVE FRAMEWORK STUDY

AREAS TO WHICH FIGURES 28 AND 29 APPLY

YAKIMA SUBREGION 3

1970

FIGURE 30

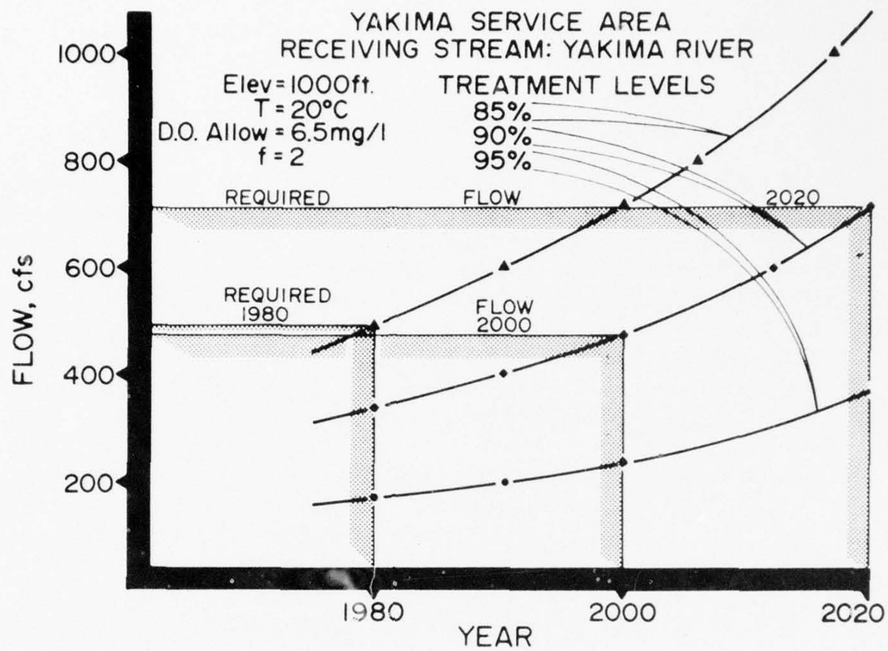


FIGURE 31. Minimum Flow Needs for Water Quality Control--Yakima River at Yakima

other means of controlling quality are necessary. Research is currently being conducted to develop methods of applying irrigation waters, fertilizers, and pesticides that will improve the quality of the return flows.

Rural waste will be of major significance in the subregion. The disposal of rural waste to septic tanks and drainage fields will continue to represent a hazard to the ground-water aquifer. High ground-water levels resulting from irrigation flows create additional problems with the subsurface waste disposal systems. Discharging higher quality effluent than septic tank effluent to the drainage fields would help to correct the problem.

The large animal population in the subregion represents the largest potential source of organic wastes; however, most of the waste reduction remains on the land and does not reach the waterways. This situation is rapidly changing with the increased use of feedlots. The animals are concentrated in greater numbers in smaller areas, and waste disposal is a problem. Fences and simple retaining structures between the animal habitat and watercourses should be provided in order to prevent bank erosion and to limit

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direct surface drainage to the stream. The waste must be collected for treatment or to be spread on the land as a soil conditioner.

Minimum Flow Requirements

Since waste treatment does not provide an economic solution for complete removal of contaminants from waste streams and provides no control of waste discharges from non-point sources, some streamflow is necessary for dilution and assimilation of residual wastes. The minimum flow requirements for assimilation of wastes are related to a number of factors, including the strength and deoxygenation capacity of the wastes; and the temperature, reaeration capacity, elevation, and minimum allowable dissolved oxygen concentration of the receiving stream.

A set of generalized curves showing minimum flow requirements for waste loadings subjected to various treatment levels is presented in figures 28 and 29. Figure 30 shows generalized areas to which the graphs are applicable. The curves designated for 1,000 feet can be used on the area which is below 1,500 feet and the 2,000-foot curves on the area above 1,500 feet.

Yakima Service Area

The population of the Yakima Service Area is projected to increase from 79,100 in 1965 to 213,000 in 2020. The food-processing industry will continue to represent the major industrial waste source, with an estimated raw waste production of 1,040,000 PE in 2020.

Figure 31 shows the minimum streamflow requirements for 1980, 2000, and 2020 for assimilation of organic waste.

Other Minimum Flow Requirements

In the preceding section, only oxygen-demanding wastes from a controllable source were considered in developing the set of generalized curves for determining minimum streamflows. Wastes from irrigation return flows, feedlots, and other non-controlled sources also deteriorate water quality by contributing organics, nutrients, coliform bacteria, and turbidity; and by increasing water temperature. In addition, a variety of chemical substances are applied to the lands during the growing season for such purposes as insect control in forests, insect and weed control on agricultural lands, and weed control in irrigation channels. Many of these chemicals are flushed into the streams. Minimum flows are required to dilute and assimilate these wastes.

It appears that more efficient application of irrigation water should be employed which will reduce the return flows and leave more water available for higher minimum streamflows.

Management Practices

The state occupies a strategic position in water quality management. It is the focal point and has a major responsibility for water pollution control. The capacity to control the water resources is an important factor in preserving water quality of the streams. Minimum streamflows must be guaranteed both now and in the future to assimilate the waste that enters the streams.

Stronger land use controls and other associated controls must be developed: (1) that give significant attention to the physical capabilities of the water; and (2) that give protection to the various uses of water. Conflicting uses of water will increase in future years as the demand for water increases.

LOCATION MAP

SUBREGION 4

SUBREGION 4

UPPER SNAKE

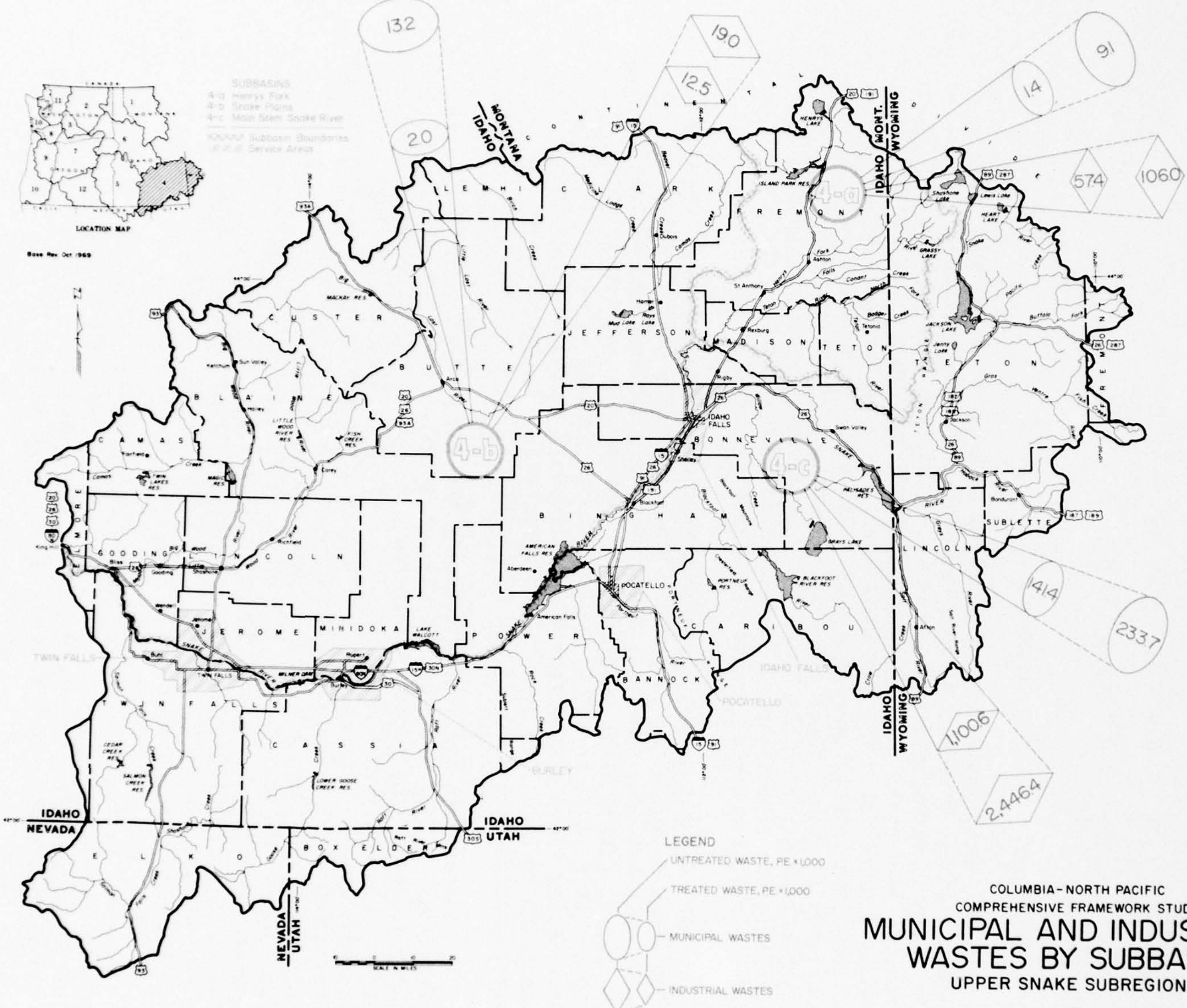
INTRODUCTION

The Upper Snake Subregion drains an area of 35,857 square miles in Idaho, Wyoming, Nevada, and Utah. The Snake River is the dominant stream traversing the subregion from east to west. From its headwaters in Yellowstone National Park, the river flows some 500 miles, skirting the Snake River Plain on the south before it leaves the subregion on the west. The major tributaries are generally in the southern and eastern portions of the subregion. A large area north of the Snake River is drained by streams which sink into the lava fields. The extensive aquifer beneath the Snake River Plain is a distinguished hydrologic feature.

The climate varies throughout the subregion because of its size and wide range in elevations. The climate is characterized by warm-to-hot, dry summers and cold winters, during which most of the precipitation falls. Extreme temperatures recorded range from -60 to 110°F. (-51 to 43° C.). The average growing season on the Snake River Plain ranges from 140 to 150 days at the lower end of the plain to about 100 days at the upper end. The average annual precipitation ranges from 10 to 60 inches.

Agriculture and food-processing are the primary economic activities. There are over two million acres of irrigated land. The principal crops grown and processed are potatoes and sugar beets. The National Reactor Testing Station is also an important economic factor. The phosphate industry in southeastern Idaho is the center of western phosphate resources and production. Recreation and tourism are important segments of the economy. Grand Teton National Park, a portion of Yellowstone National Park, Craters of the Moon National Monument, and several National forests are significant attractions. In addition, the subregion also contains two of the Nation's best winter sport areas (Jackson Hole and Sun Valley).

The total population of the subregion is about 302,000 people. About 49 percent reside in the four major service areas. The population density in the remainder of the area is low--often less than one person per square mile in large areas.



COLUMBIA-NORTH PACIFIC
COMPREHENSIVE FRAMEWORK STUDY

MUNICIPAL AND INDUSTRIAL WASTES BY SUBBASIN

UPPER SNAKE SUBREGION 4

1969

FIGURE 32

The Upper Snake Subregion (figure 32) is divided into the Henrys Fork, Snake Plains, and Main Stem Snake Subbasins. The major service areas are the Idaho Falls, Pocatello, Burley and Twin Falls areas.

PRESENT STATUS

The major waste sources in the Upper Snake Subregion are the food-processing industries, particularly potato processing and sugar refining; municipalities; agricultural animals; and irrigation return flows. A graphical summary of the municipal and industrial organic waste production and discharge is also presented in figure 32. The magnitude of wastes from agricultural animals and irrigation return flows is not readily identifiable.

Water pollution is relatively new to the Upper Snake Subregion; however, wastes from a concentrated population, rapid industrial growth, and a water regulation system based largely on irrigation and power needs have resulted in repeated instances of water pollution. Water quality declines moderately but progressively through the reach of the Upper Snake. Nutrient concentrations rise at a rapid rate, accounting for dense algal and weed growths; and are accompanied by increases in dissolved solids, biochemical oxygen demand, bacteria, and temperature. Dissolved oxygen concentrations are usually above levels necessary to support salmonid fish, although localized dissolved oxygen depressions have occurred.

Stream Characteristics

The Snake River, flowing westward through the subregion, has its source in the remote areas of Yellowstone Park and is fed by such major tributaries as the Gros Ventre, Hoback, and Greys Rivers in Wyoming, and Henrys Fork, Blackfoot, Portneuf, Big Wood, Buffalo Fork, and Salt Rivers in Idaho. In the north-central portion of the subregion, the Big Lost and Little Lost Rivers, Birch Creek, and several other streams have no surface outlet to the Snake River, but disappear into the very porous soil in the desert area of Butte and Jefferson Counties.

At Heise, where the flow of the Snake River is measured above irrigation diversions in Idaho, the average annual discharge is about 4.7 million acre-feet. Below Milner Dam, some 250 miles downstream, a residual flow averaging 1.1 million acre-feet remains after irrigation diversions and natural losses to ground water. Below Milner, substantial inflow--principally from large springs--increases the average flow of the Snake River to about 6.2 million acre-feet at King Hill.

Surface-Water Hydrology

The seasonal runoff pattern for most of the Upper Snake Subregion is modified by storage regulation, which outweighs natural influences in determining the pattern of runoff. The flood that occurs when spring rains release and augment snowmelt, the natural foundation of flows, is captured in a network of irrigation and flood control reservoirs and distributed through the summer. In the fall, the continuing influence of irrigation return flows acts to maintain stream levels; winter streamflows are restricted severely as reservoirs are filled and return flows diminish. Though summer flows are high at points below impoundments, high summer flows are not an unvarying situation. Below significant diversion points, summer flows may cease entirely at times. Table 60 summarizes mean monthly discharge data for selected stations.

Table 60 - Mean Monthly Discharge, Subregion 4 (12)

Location	Jan.	Feb.	March	April	May	June	July (CFS)	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
Snake River at Moran, Wyoming	456	145	107	203	1,435	3,195	3,082	3,244	3,138	432	413	435	1,362
Snake River at Idaho-Wyoming State Line	1,806	1,449	1,468	3,776	10,037	13,200	8,243	5,665	5,150	2,360	2,128	1,946	4,780
Snake River near Heise, Idaho	2,759	2,545	2,522	5,310	11,782	13,380	12,153	9,720	7,866	3,691	3,048	2,860	6,489
Henrys Fork near Rexburg, Ida.	1,364	1,463	1,590	1,931	2,658	2,130	972	826	1,058	1,372	1,439	1,349	1,512
Blackfoot River near Blackfoot, Ida.	131	129	147	280	233	130	36	51	61	181	267	200	154
Portneuf River at Pocatello, Idaho	260	297	367	459	370	170	70	78	102	160	240	262	236
Snake River at Neeley, Idaho	1,786	2,549	4,035	8,171	11,600	11,227	12,693	11,634	6,539	2,850	837	1,054	6,271
Snake River at Milner, Idaho	2,140	2,964	3,885	3,879	1,308	212	328	329	90	1,037	1,009	1,452	1,545
Big Lost River near Mackay, Idaho	119	127	134	144	439	871	624	377	186	136	87	100	279
Big Wood River near Gooding, Idaho	88	157	305	576	495	313	76	50	80	43	101	93	198
Snake River at King Hill, Idaho	8,922	9,593	10,471	10,498	7,987	7,320	7,227	7,545	7,904	8,814	8,418	8,458	8,590

One-in-ten-year low flow is the selected recurrence frequency to predict critical low flows (table 61). However, occurrence of low flows critical to quality control is largely a function of the management regimen of the subregion's waters. Low flows are frequently the result of withholding water to build up storage for irrigation or of the actual diversion of a significant part of a stream to the fields.

Impoundments and Stream Regulation

The Upper Snake River is an intensely regulated drainage system. There are 25 existing structures which have storage capacities of 5,000 acre-feet or more. Active storage amounts to about 5.1 million acre-feet. Development has been directed largely to irrigation, and 21 of the major storage structures are principally for this purpose. The high level of irrigation storage capacity is accompanied by corresponding diversion capacity. No storage is authorized for water quality control, although incidental benefits result from releases for other purposes. The releases of stored water for irrigation during the summer low streamflow period have improved water quality in several tributaries. In fact, some tributaries would have no summer flows without storage. However, the considerable alteration that has been imposed on the flow pattern has two significant detrimental effects: winter flows are diminished during the period of maximum food-processing waste production as reservoirs are filled for the irrigation season; and summer flows are sometimes partially or completely depleted at points below irrigation diversions.

Table 61 - One-in-Ten-Year Low Flows 1/, Subregion 4 (12)

Stream and Location	One-in-Ten-Year Low Flow (cfs)
Snake River at Moran, Wyoming	35
Snake River at Idaho-Wyoming State Line	1,170
Snake River near Heise, Idaho	1,280
Henrys Fork near Rexburg, Idaho	330
Blackfoot River near Blackfoot, Idaho	< 4
Portneuf River at Pocatello, Idaho	35
Snake River at Neeley, Idaho	< 100
Snake River at Milner, Idaho	< 5
Big Lost River near Mackay, Idaho	50
Big Wood River near Gooding, Idaho	< 10
Snake River at King Hill, Idaho	6,200

1/ Period of 1 month

The most serious pollution problems associated with impoundments and stream regulations have occurred in the Snake River at Milner and American Falls Reservoirs and below the Idaho Falls Service Area; and in the lower reaches of the Henrys Fork and South Fork Teton Rivers. In Milner Reservoir, a combination

of inadequately treated municipal and industrial wastes and extremely low flow releases from the reservoir has resulted in dissolved oxygen depressions and fish kills. Heavy algal growths in American Falls Reservoir have resulted in wide diurnal fluctuations in the dissolved oxygen concentration, which caused a fish kill in 1967. In the Snake River below Idaho Falls and in the Henrys Fork and South Fork Teton Rivers, complete flow interruptions for maintenance of head gates at irrigation diversions, in combination with residual municipal and industrial waste loadings, have resulted in pollution conditions.

Ground-Water Characteristics

There are four major aquifer units of importance in the utilization of ground water in Subregion 4. The two younger units, the alluvium and the Snake River basalt, are major aquifer units throughout much of the subregion. These aquifers support very large developments, especially for irrigation. Well yields are commonly from 1,000 to 3,000 gpm. In some places the lacustrine deposits yield acceptable quantities of water for irrigation.

Silicic volcanic rocks crop out over extensive areas, chiefly south of and around the eastern margin of the Snake River Plain. This unit yields large supplies of water to wells southeast of Rexburg.

The younger consolidated and semi-consolidated sedimentary strata crop out widely south of the Snake River Plain. Generally, these yield only small supplies of water.

The waters of all aquifer units in the subregion are generally of excellent quality. In general, the only quality problems associated with ground-water sources are local bacteriological contamination from humans, livestock, or irrigation where the high porosity of soils allows the rapid movement of bacteria to the aquifers. Careful monitoring of ground-water sources is needed in several areas to prevent the occurrence of severe public health hazards. Concern has also been expressed in the Snake Plains about the disposal to ground waters of low-level radioactive wastes from the National Reactor Testing Station.

A more detailed discussion of ground water in Subregion 4 is presented in Appendix V.

Pollution Sources

Municipal and industrial waste production and discharges, in population equivalents, are summarized by subbasin in table 62. At present, municipalities and industries produce wastes equivalent to those from a population of 2.83 million persons. Of this total, 91 percent is generated by the food-processing industry, including 66 percent by potato-processing and 19 percent by sugar-refining; and 5 percent originates from municipal sources.

Waste treatment and other means of waste reduction decrease the total organic load to the subregion's waters by about 53 percent, so that 1.32 million population equivalents actually reach waterways. Of this total, 144,800 PE are released by municipalities, and 1,170,450 PE are discharged by industries.

Municipalities

Treatment practices are generally adequate, with the exception of several communities having no waste collection or treatment systems. Most notable among these are the cities of Ketchum, Hailey, and Shoshone with populations of about 750, 1,190, and 1,420 persons, respectively. However, Ketchum and Hailey have received grants for construction of interceptors and lagoons.

Main Stem Snake Subbasin Approximately 116,130 persons, or 51 percent of the population of the Main Stem Snake Subbasin, are served by municipal waste treatment facilities. Of the 22 municipal waste systems, three presently provide secondary treatment; however, two of these facilities need enlargement or replacement to handle current loads. All eight communities having primary plants must convert to secondary treatment in order to meet minimum State Water Quality Standards. Ten communities have lagoons, which generally achieve an adequate treatment level. One community provides a septic tank, but must convert to secondary treatment to satisfy minimum standards.

Municipal waste sources account for a waste loading of about 141,400 PE to the waters of the subbasin. In general, waste loading points tend to be discrete, well separated, and characterized by concentrated, rapidly growing waste loads. A large portion of this municipal oxygen-demanding load can be attributed to industries which discharge wastes to municipal systems. In many cases, this combined treatment results in economic and treatment efficiency advantages for both municipalities and industries.

In the Wyoming headwaters and tributaries of the Snake, municipal waste sources are few; the only communities with

Table 62 - Summary of Municipal and Industrial Waste Treatment, Subregion 4 1/

	Municipal					Industrial			
						Food Processing			
	Primary	Secondary	Lagoons	Other	Total	Sugar	Potato	Other	Total
Henrys Fork Subbasin									
Number of facilities	0	0	4	1	5	0	2	3	5
Population served	0	0	7,000	820	7,820				
PE produced	0	0	9,100	-	9,100	0	105,000	1,000	106,000
PE discharged	0	0	1,360	-	1,360	0	57,000	400	57,400
% removal efficiency	-	-	85	-	85	-	46	60	46
Snake Plain Subbasin									
Number of facilities	1	3	1	1	6	0	0	4	4
Population served	1,500	5,400	600	4,670	12,170				
PE produced	1,500	6,400	600	4,670	13,170	0	0	19,000	19,000
PE discharged	1,000	980	60	0	2,040	0	0	12,500	12,500
% removal efficiency	33	85	90	100	84	-	-	34	34
Main Stem Snake Subbasin									
Number of facilities	8	3	10	1	22	3	19	25	47
Population served	90,140	7,300	17,790	900	116,130				
PE produced	179,940	25,300	27,290	1,200	233,730	540,000	1,773,000	133,350	2,446,350
PE discharged	127,070	10,430	2,800	1,100	141,400	321,000	757,300	22,250	1,100,550
% removal efficiency	29	59	90	8	40	40	58	83	55
Total									
Number of facilities	9	6	15	3	33	3	21	32	56
Population served	91,640	12,700	25,390	6,390	136,120				
PE produced	181,440	31,700	36,990	5,870	256,000	540,000	1,878,000	153,350	2,571,350
PE discharged	128,070	11,410	4,220	1,100	144,800	321,000	814,300	35,150	1,170,450
% removal efficiency	29	65	89	81	43	40	56	77	54

1/ FWPCA inventory of Municipal and Industrial Wastes, Upper Snake Subregion, 1965.

municipal waste treatment systems are Jackson and Afton, both of which provide adequate treatment. In the Idaho portion of the subregion, the first potential waste source is the Rigby area, including the communities of Rigby, Menan, Ririe, and Lewisville, Idaho. However, adequate waste treatment is practiced by these municipalities so that organic loadings to the Snake are very minor.

The Idaho Falls Service Area is a major source of municipal wastes in the subbasin. An average waste loading of about 18,000 PE is discharged from the Idaho Falls primary treatment plant into the Snake River. The Idaho Department of Health has recommended secondary treatment by 1972. In and near the City of Idaho Falls, there have been persistent problems of drainage and ground-water contamination. The recent installation of separate storm sewers which discharge to dry wells in the vicinity of Idaho Falls has contributed to the problem of ground-water contamination. Also, the nearby towns of Iona, Ucon, and Ammon are unsewered, and their residents utilize individual ground disposal of wastes. The Idaho Department of Health, in considering the problem, has suggested that the combined sewers, while objectionable in principle, are preferable to ground-water contamination. Also within the service area, the City of Shelley utilizes a waste stabilization pond. A portion of the wastes of a potato-processing plant at Shelley is routed into the city ponds, achieving a reduction in biochemical oxygen demand somewhat above the usual level.

The Blackfoot area, which is located between Idaho Falls and the head of American Falls Reservoir, contributes an organic loading of about 6,000 PE to the Snake River. The community has a primary treatment plant, but the Idaho Department of Health requires that the facility be upgraded to secondary treatment by 1973.

The City of Pocatello has a primary treatment plant that discharges about 27,000 PE to the Portneuf River. The city transports treated wastes to a discharge point below the major groundwater influx to the Portneuf River to obtain additional dilution of its wastes. The Idaho Water Quality Standards have listed the community as in need of secondary treatment. Pocatello's municipal airport sewers untreated wastes directly to the river. The village of Inkom, above the service area, also discharges to the river without treatment. However, the community has received a grant for construction of interceptors and lagoons.

Below the American Falls Reservoir, the communities of American Falls and Aberdeen represent minor waste sources. The City of American Falls discharges wastes from an efficient secondary treatment plant to the substantial flows below the American Falls Dam. The City of Aberdeen provides a community septic tank. The effluent from the septic tank, coupled with food-processing wastes, results in a severe, though localized, water pollution problem in the Aberdeen Drain and American Falls Reservoir. The Idaho Department of Health requires that Aberdeen must install secondary treatment by 1970.

The Burley Service Area, located at Milner Reservoir, is a moderate source of municipal wastes. A total of about 5,200 PE is discharged to the subbasin's waterways from municipalities in the area. Burley has very effective lagoons; and Rupert, Paul, and Heyburn provide primary treatment plants. The three primary facilities must be upgraded to secondary treatment or the equivalent to meet minimum requirements of the Idaho Department of Health. Burley and Heyburn release wastes directly to Milner Reservoir, and Rupert and Paul discharge wastes to Main Drain, which is an irrigation return canal discharging into Milner Pool.

The Twin Falls Service Area, which includes the cities of Twin Falls, Kimberly, Hansen, Filer, and Jerome, is the major municipal waste source in the subbasin. A total of about 82,000 PE is discharged to waterways from the service area. The primary waste treatment plant at Twin Falls discharges about 70,000 PE to the river. The high organic loads released by Twin Falls are largely attributed to industries that discharge wastes to the municipal system. The Idaho Department of Health requires secondary treatment at Twin Falls by 1973.

Other From the Twin Falls Service Area to the boundary of the Upper Snake Subregion, there are no significant municipal waste sources along the Snake River.

Industries

Henrys Fork Subbasin Major industrial waste sources in the Henrys Fork Subbasin are limited to the potato-processing industry, and minor sources include dairies and slaughterhouses. An oxygen-demanding load of approximately 57,400 PE is discharged to waterways at peak periods of waste production.

A potato-processing plant at Rexburg is the principal industrial waste source. An average of about 27,000 PE is released from the plant's lagoons and primary treatment facility into the South Fork of the Teton River. The Idaho Department of Health requires that secondary treatment or the equivalent be installed by 1971. The plant does not operate during much of the summer low-flow period.

A starch company at St. Anthony operates intermittently. When in operation, an organic loading of about 30,000 PE is discharged to the Henrys Fork. The plant provides only process controls for its difficult-to-treat wastes. The Idaho Department of Health required that primary treatment for silt removal be provided in 1968, and that secondary treatment or the equivalent be installed by 1972.

Minor waste sources include dairy-processing plants at Rexburg, St. Anthony, Driggs, and Ashton; a small potato cannery at Parker; and local slaughterhouses. Dairy processors sometimes practice the discharge of whey from cheese-making operations without prior treatment. Slaughterhouses and dairies generally provide only septic tanks for treatment.

Snake Plain Subbasin Industrial production of biochemical oxygen-demanding wastes in the Snake Plain Subbasin is limited. The only waste sources are associated with the dairy products and meat-packing industries. A total organic loading of 12,500 PE is discharged by these industries into the Little Wood River. A food company at Carey and a creamery at Richfield release 1,000 and 500 PE, respectively, without treatment. Two packing companies at Gooding discharge 5,000 and 6,000 PE after treatment in lagoons. No serious degradation of water quality has resulted from these discharges.

The National Reactor Testing Station is a significant source of radioactive wastes. The NRTS is engaged in three lines of

reactor development; testing irradiation services, chemical processing for recovery of enriched uranium from partially utilized reactor fuels, and examinations into the inherent safety of nuclear systems, including the development of safeguard devices and methods predicting safe reactor limits. Table 63 summarizes waste disposal practices and quantities of radioactive waste discharged monthly. Low-level liquid radioactive wastes are released to the ground-water table from wells and seepage ponds after careful monitoring. In addition, wells serving the facilities and off-site sampling locations are included in a systematic program of water sampling and analysis. Off-site sampling has been pursued since 1952, and no evidence of NRTS addition to natural radioactivity has been found. As a result, the NRTS during 1966 curtailed the number of its off-site sampling locations. Among others, all of the stations sampling the main source of ground-water inflow in the Thousand Springs area were eliminated. While no problems of ground-water contamination have ever been reported, the exotic nature of the wastes discharged, the lack of knowledge of the behavior of water and radionuclides in the aquifer, the opportunities for accident in a situation marked by transfer of high-level liquid radioactive wastes, and the discharge of dilute materials or protective storage of concentrated materials as handling expedients for radioactive wastes, all give rise to a concern as to the overall adequacy of the NRTS waste control programs. In sum, liquid radioactive wastes discharged to the aquifer each year contain about 5,100 curies of radioactivity. To add to the total radioactivity of liquid wastes, some solid wastes are disposed of by burying, and these may be subject to leaching. Under these conditions, the buildup of radioactivity in underground reservoirs and the possibility of an accidental discharge of high-level-radioactive liquids are a threat to the southern Idaho area.

Table 63 - Summary of Liquid Radioactive Waste Disposal
National Reactor Testing Station, Idaho, Subregion 4

	Mean Monthly Waste Discharge (Average 1961-65)		
	Million Gallons	Curies	Disposal
Central facilities area	4.0	0.34	Sewage system--subsurface irrigation field
Test reactor area	17.3	350	Seepage ponds
Chemical processing plant	24.4	60	600-foot well
Chemical processing plant	0.2	7.6	Seepage pits
Naval reactor facility	2.3	3.1	Seepage pond
Test area north	2.3	0.3	Wells
Argonne National Lab.	11.6	0.01	Seepage pit
Per month	62.1	421.35	

Main Stem Snake Subbasin The Main Stem Snake Subbasin is the principal area of industrial waste production in Subregion 4. In general, waste loading points in the subbasin tend to be discrete and well separated. The four service areas discharge about 94 percent of the total industrial waste load. The potato-processing industry is the major waste source, discharging about 757,300 PE from 19 plants. Three sugar refineries account for an additional waste discharge of 321,000 PE. A number of food-processing plants, including dairies and slaughterhouses, also discharge significant oxygen-demanding waste loadings. The phosphate industry in the Pocatello Service Area discharges inorganic wastes which have a significant influence on water quality in the Snake. Treatment practices are generally fair, accomplishing an overall reduction of about 55 percent of the total biochemical oxygen demand. However, the Idaho Department of Health requires that most industries provide secondary treatment or the equivalent within the next 5 years.

In the Wyoming headwaters and tributaries of the Snake, industrial waste sources are few. The only significant waste source is a cheese factory at Thayne, which must upgrade its lagoon treatment. The first major industrial waste source downstream is in the Rigby area, which supports a potato-processing plant and several minor food-processing plants. Waste treatment practices in the Rigby area are deficient in that the largest source of wastes--a potato-processing plant at Lewisville--treats wastes only through fine screening and a settling pond, rather than with the considerably more efficient mechanical clarifier used by most potato-processing plants. The plant discharges its wastes to a small drainage ditch, which often becomes septic. In addition, a cheese plant at Ririe has no waste treatment. The Idaho Department of Health requires that the Lewisville potato-processing plant provide secondary treatment or the equivalent by 1971.

The Idaho Falls Service Area is a major source of industrial wastes in the Main Stem Snake Subbasin. Wastes entering the Snake include those from three potato-processing plants, a sugar refinery, two potato starch plants, several dairies, and meat-packing plants. In sum, these sources produce about 750,000 PE of wastes through fall and winter, an amount that is reduced to about 390,000 PE of residual waste discharge to the river. In general, the service area maintains a primary level of waste treatment; however, several industries do not reach the level of waste removal provided by effective primary treatment. The Idaho Department of Health has an implementation plan requiring primary treatment for some industries now and secondary treatment for all industries between 1971 and 1973.

Below the Idaho Falls Service Area, the Blackfoot area represents a significant industrial waste source. A potato company discharges about 72,000 PE to the Snake River after primary treatment. Silt removal facilities are required, and secondary treatment or the equivalent is to be installed by 1973. A potato starch plant provides only process controls of wastes. The plant operates intermittently, discharging about 9,000 PE to the Snake when in operation. Primary treatment for silt removal is required, and secondary treatment or the equivalent is required by 1973.

The Portneuf River, a major tributary of the Snake, enters at American Falls Reservoir carrying heavy waste loads. Only a moderate level of organic industrial wastes, mainly from packing houses and dairy processors, is present. The most significant waste loads are from phosphate-processing plants. One of the largest of Idaho's six phosphate refiners produces fertilizers, phosphoric acid, and phosphorous compounds with a process of sulfuric acid leaching of phosphates from ores. One installation produces elemental phosphorous, utilizing electric furnaces.

The wet-acid process utilized by one phosphate-processing plant produces a number of undesirable waterborne waste products. Gypsum constituents of the phosphate-bearing rock are carried in high concentrations in the waste stream. These rapidly settle out, forming unsightly, life-smothering sludge beds. Effluent temperature is sometimes over 100° F. (37°C.). The leaching agent, sulfuric acid, results in a highly acid effluent flow. Fluorides bound up in phosphate rock are released in the leaching process, and carried by the waste stream, as residual phosphate, a prime nutrient material utilized by aquatic vegetation. Facilities were constructed in late 1965 to provide treatment for about half of the plant's waste stream. Treatment consists of solids concentration and recirculation of overflows. Subsidiary facilities include cooling towers and large areas of settling ponds into which waste can be pumped in the event that clarifier facilities are overtaxed. While these facilities represent a definite improvement, they extend to only a portion of the total liquid wastes of the plant. The untreated effluent constitutes a significant fraction of the total flow of the Portneuf River at the point that it enters the stream. Though waste treatment methods that have been developed are lacking in terms of control of solids and nutrients, they appear to be effective in limiting fluoride discharges.

Liquid wastes from some of the plants are of minor significance, since the installation utilizes an electrolytic process whose major water requirement is for cooling. Cooling waters are cycled back through stock scrubbers and thence into settling ponds whose overflow is treated with lime to maintain an effluent pH above 8.0. No problems of disposal have been noted.

Below the American Falls Reservoir, industries in the American Falls area have little effect on the water quality of the Snake River. A large potato-processing plant near American Falls utilizes a non-overflow lagoon. This facility has been objected to as an odorous nuisance and a possible source of ground-water contamination, but it does not affect the quality of any watercourses. The Idaho Department of Health requires that primary treatment and improved land disposal techniques be installed. A potato-processing plant, a potato starch company, and a dairy discharge wastes to Aberdeen Drain, a very limited watercourse with flow derived principally from irrigation returns. Treatment includes effective primary treatment for the potato-processing plant, but no controls for wastes of the potato starch company and the dairy. The Idaho Department of Health requires that secondary treatment or the equivalent be provided for the plants by 1970.

The Burley Service Area, located along Milner Reservoir, represents a significant industrial pollution source. At the City of Burley, four large potato-processing plants line the Snake River. Another is located at Heyburn, directly across the Snake River from Burley. North of the river a large sugar refinery is located at Paul, and a moderately sized potato-processing plant is situated at Rupert. Three dairy products plants, a couple of small slaughterhouses, a flour mill, and several potato warehouses also add to the waste loads imposed on the Snake River at Milner Reservoir. About 260,000 PE are discharged into Milner Reservoir from industrial sources, and another 26,000 PE are released to Main Drain, which flows into Milner Reservoir. Most of this waste load is discharged in winter, when potato processing and sugar refining are at their peaks, and when flow through the reservoir is lowest.

The Idaho Department of Health requires secondary treatment or the equivalent for processing plants in the Burley Service Area. Adequate treatment is presently practiced at a sugar company's waste stabilization ponds. Secondary waste treatment by potato processors has been delayed pending the outcome of extended research into methods to provide higher degrees of removal without incurring extreme costs. A plant at Burley is being used to conduct studies of secondary treatment methods for potato wastes.

Industrial wastes in the Twin Falls Service Area do not significantly affect the water quality of the Snake River. Most of the area's major industrial plants have primary waste treatment. The principal exception is a sugar company refinery near Twin Falls. The plant discharges about 185,000 PE without treatment to Rock Creek. This practice has resulted in Rock Creek being an unsightly nuisance. The Idaho Department of Health requires that primary treatment be installed at the plant by mid-1969. Concern has been expressed about the adequacy of the deep-well disposal methods

used by an intermittently operating frozen foods company at Kimberly. The area in doubt has a history of ground-water contamination. The plant is to provide secondary treatment or the equivalent by mid-1973. Several other industries in the area are listed in the Idaho Water Quality Standards as in need of secondary treatment or the equivalent. A corn-processing company employs highly effective crop irrigation techniques for disposal of liquid corn-processing wastes.

Rural-Domestic

Approximately 165,900 persons, or 55 percent of the subregion's population, are not connected to municipal waste treatment facilities. Table 64 summarizes by subbasin the population and the percent of subbasin and subregion population served by individual sewage disposal systems. In general, septic tanks and some type of subsurface drainage are used for waste disposal. The actual waste load reaching waterways from rural-domestic sources is not considered to be large.

Table 64 - Summary of Population Served by Individual Waste Disposal Systems, Subregion 4 1/

Subbasin	Population Served Thousands	Percent Subbasin Population	Percent Subregion Population
Henrys Fork	13.2	62.8	4.4
Snake Plain	45.8	79.0	15.2
Main Stem Snake	106.9	47.9	35.4
Total	165.9		55.0

1/ Derived as a residual from FPCA Municipal and Industrial Waste Inventory, Upper Snake Subregion, 1965.

Irrigation

Approximately 2,485,000 acres are presently irrigated in the Upper Snake Subregion; this requires an annual diversion of 13.5 million acre-feet of water. Ridge and furrow methods of irrigation are practiced on about 80 percent of the irrigated land, and most of the remaining land is generally irrigated by sprinkler methods. Flood irrigation of pasturelands is practiced in the Marsh Valley and the upper Portneuf River drainage and in other areas where there are inadequate storage facilities.

Twofold to fourfold increases in total dissolved solids concentrations and chloride concentrations have been measured in Raft and Blackfoot Rivers and several other Upper Snake River tributaries used heavily for irrigation. The dissolved solids content of the Snake River increases from about 175 mg/l at the Idaho-Wyoming border to about 400 mg/l at Buhl, Idaho. Also, areas in which irrigation has been developed are generally those in which sedimentation is pronounced.

The approximately 36 percent consumptive use of irrigation water is pollutional in a secondary way through the lessening of the amount of water available as a solvent. This is of particular importance in the Upper Snake, where irrigation far outweighs any other use of water in gross amount required and in depletion of flows.

Agricultural Animals

Agricultural animal waste drainages in the Upper Snake Subregion are an important source of coliform bacteria and a source of some portion of biochemical oxygen demand. The estimated organic waste potential of the animal population is equivalent to that from a population of 5.5 million people. An estimated 95 percent of the wastes generated are reduced by deposit to the land and natural decomposition, so that about 275,000 PE eventually reach waterways. Grazing and feeding of farm animals are considered to be a major waste source, but their impact on water quality is difficult to determine. Although the animal population is generally diffused throughout the subregion, concentrations occur along the Snake River between Minidoka Reservoir and the mouth of the Big Wood River. In this area there are approximately 275,000 cattle and a significant number of other farm animals. Their relative closeness to the river in this area laced with irrigation drains increases the possibility of these wastes representing a significant pollutional source.

There are several feedlots in the subregion which accommodate two thousand or more animals at a time. Where they are located, feedlots along streambanks without minimal control afforded by fencing animals from the water, high biochemical oxygen-demanding wastes, coliform bacteria, high levels of nutrients, and solids are flushed into streams with significant effects on water quality.

Other Land Use and Management

The production and transport of sediment are the most significant quality impairments resulting from land-use practices in the Upper Snake. (9) However, limited studies indicate that the subregion is characterized by a low rate of sediment yield, except for the more steeply sloping agricultural land. The latter is especially vulnerable during years when land in winter wheat or fallow becomes frozen, and then thaw is accompanied by snowmelt or rain. Annual average sediment yield varies from less than 0.1 acre-foot per square mile per year up to about 0.5 acre-foot per square mile per year. Actual sediment contribution from much of the area of southern Idaho is unknown. However, Marsh Creek, which empties into the Portneuf River near Inkom, carries heavy loads of silt. The major source of sediment in Marsh Creek Valley is believed to be caused by sheet and gully erosion on the dry-farmed bench on the west side of the valley.

Natural Sources

Richly productive, the waters of the Upper Snake system are characterized by massive growths of algae and by fixed and floating water weeds that constitute the most obvious type of water quality alteration in the subregion. Excessive algal growths are largely a result of high nutrient concentrations that exist in the subregion. The threshold levels of phosphates and nitrates are exceeded through most of the Snake River and tributaries. High natural backgrounds are indicated by the considerable weight of the material present in upstream areas. Also, ground-water inflows may be a major influence on the progressive rise of nutrients downstream in the Snake River.

The Blackfoot River, which enters the Snake between Idaho Falls and the head of American Falls Reservoir, is characterized by high phosphate concentrations and by heavy growths of grasses and water weeds. The source of this problem is in the Blackfoot Reservoir, which is located on a seam of phosphate-bearing earths. The reservoir also supports heavy growths of algae.

Present Water Quality

Quality of the waters of the Upper Snake River and its tributaries is generally suitable in most stream reaches for the uses made of those waters. The most serious and extensive symptom of water quality degradation is excessive production of aquatic vegetation, which is manifested in slime-like floating masses, discolored waters, and heavy rooted bottom growths throughout the

southern sweep of the Snake River and in the lower reaches of tributaries entering the Snake in that area. Significant sediment and mineral loads occur in the same reaches throughout the irrigation season and during the period of maximum snowmelt. Bacterial concentrations are above recommended recreational limits near a number of populated areas, and dissolved oxygen deficiencies have occurred intermittently at a number of points.

With the exception of aquatic growths and sedimentation, there have been few instances of persistent or recurring water quality degradation in recent years. Milner Reservoir and the lower Portneuf River have consistently demonstrated some undesirable water quality conditions at least part of the year. Most other water quality problems in the subregion have been limited to local nuisance conditions.

Main Stem Snake River

In general, the quality of the Upper Snake River deteriorates progressively as it flows through the subregion and is subjected to intensive use. This degradation in quality of the Upper Snake has little influence on water quality of the Central Snake Subregion, since ground-water inflows in the Thousand Springs area, in essence, create a new river of excellent quality.

Figure 33 presents a generalized dissolved oxygen profile for the Snake River. Dissolved oxygen concentrations of the Upper Snake are usually found to be near the saturation level. However, the dissolved oxygen concentration is depressed at two points within the subregion. In summer, the oxygen level of the water behind American Falls Dam drops several milligrams per liter (mg/1) below that of the water entering the reservoir. During 1967, diurnal fluctuations in the dissolved oxygen concentration, caused by the photosynthetic and respirational cycle of algae, resulted in the depression of dissolved oxygen to the point that a fish kill occurred. In winter, flow out of Milner Reservoir drops to a minimum level, ice cover inhibits reaeration for several months; and, with large amounts of organic wastes entering the reservoir, septic conditions have resulted.

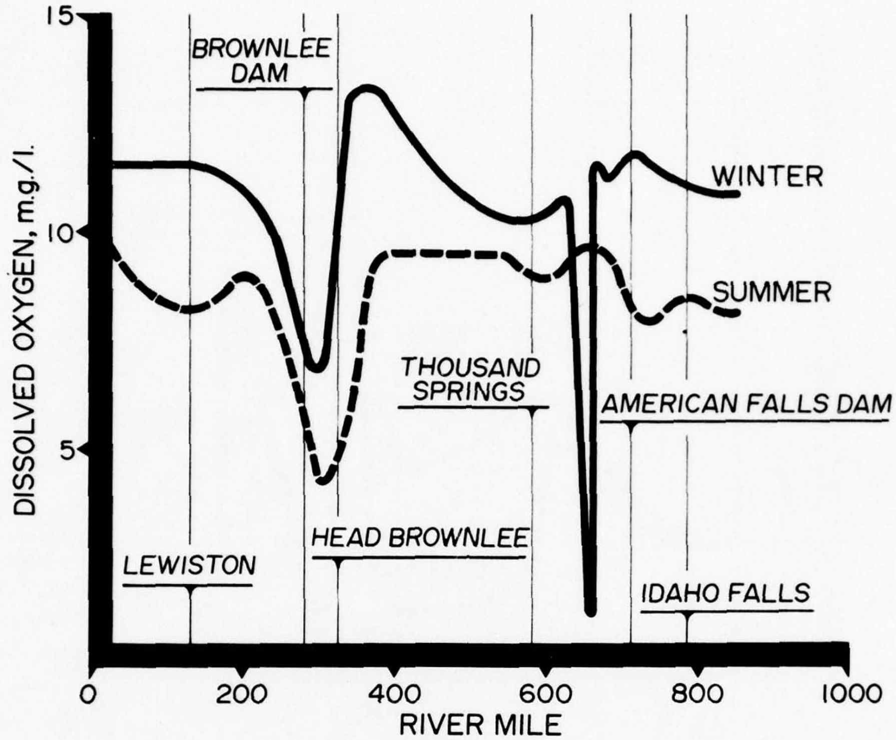


FIGURE 33. Dissolved Oxygen Profile (Generalized), Snake River.

Biochemical oxygen demand (BOD) is a measure of the oxygen-utilizing potential of organic materials present in water. Figure 34 presents a generalized biochemical oxygen demand profile for the Snake River. In winter, the BOD configuration is about what might be expected from a knowledge of waste discharges. Background levels below one mg/l rise sharply as Idaho Falls waste loads enter the river. From Idaho Falls to American Falls Reservoir, the rate of waste stabilization exceeds the rate at which degradable materials enter the stream; and in the reservoir biochemical oxygen demand recedes to background levels. In Milner Reservoir the wastes of the Burley area create a second peak, which is diluted by the inflow of ground water in the Thousand Springs area below Milner Dam. In summer, however, biochemical oxygen demand concentrations are strikingly different than would be expected from a knowledge of the greater flows and much lower industrial waste loads that occur. There is a pronounced, progressive rise in biochemical oxygen demand concentration through the Upper Snake Subregion until levels in Milner Reservoir are comparable to winter peaks below food-processing centers. Even after biochemical oxygen

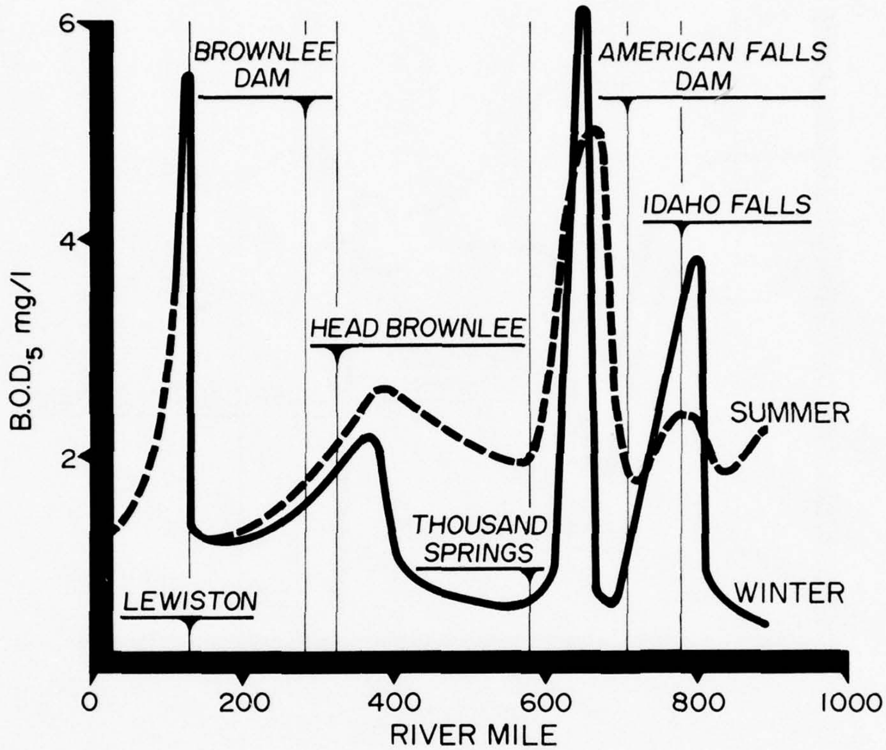


FIGURE 34. BOD Profile (Generalized), Snake River.

demand is diluted in the Thousand Springs area, it remains much higher than in winter. Unlike pronounced winter biochemical oxygen demand concentrations which appear to depress dissolved oxygen concentrations at several points, high summer biochemical oxygen demand accompanies dissolved oxygen concentrations that are typically higher than 100 percent of saturation. The situation is presumed to be due to the prolific aquatic growths found in the river. Release of oxygen in the respiratory process of aquatic plant life compensates for the oxygen demand created by decomposition of the same kinds of aquatic biota.

The bacterial quality of the Snake River is highly variable. Coliform densities below service areas are high enough that the water is considered unsuitable for water-contact recreation (greater than 1,000 MPN/100 ml). Very high bacterial concentrations are found in the Burley and Idaho Falls areas. Discharges of sanitary sewage are unquestionably responsible in some measure for high bacterial concentration throughout most of the

Upper Snake; and such sources can be, and have been, offset by more efficient disinfection. However, bacterial concentrations in the Upper Snake derive in great part from the large animal populations and from soil bacteria.

Figure 35 presents a generalized temperature profile for extreme winter and summer months under existing conditions for the Snake River. Winter temperatures are generally close to freezing except in areas where flow is derived largely from ground water. Reservoirs in the Upper Snake freeze over annually, and modest icing occurs at other ponded locations. Near the headwaters, flows derived from snowmelt remain below 60°F. (15.5°C.) during the summer. Downstream warming results from exposure to solar radiation and is accelerated by the effects of some impoundments, streamflow depletion, and irrigation return flows. At King Hill, temperatures are moderate throughout the year, reflecting the fact that most of the flow is derived from the Thousand Springs area.

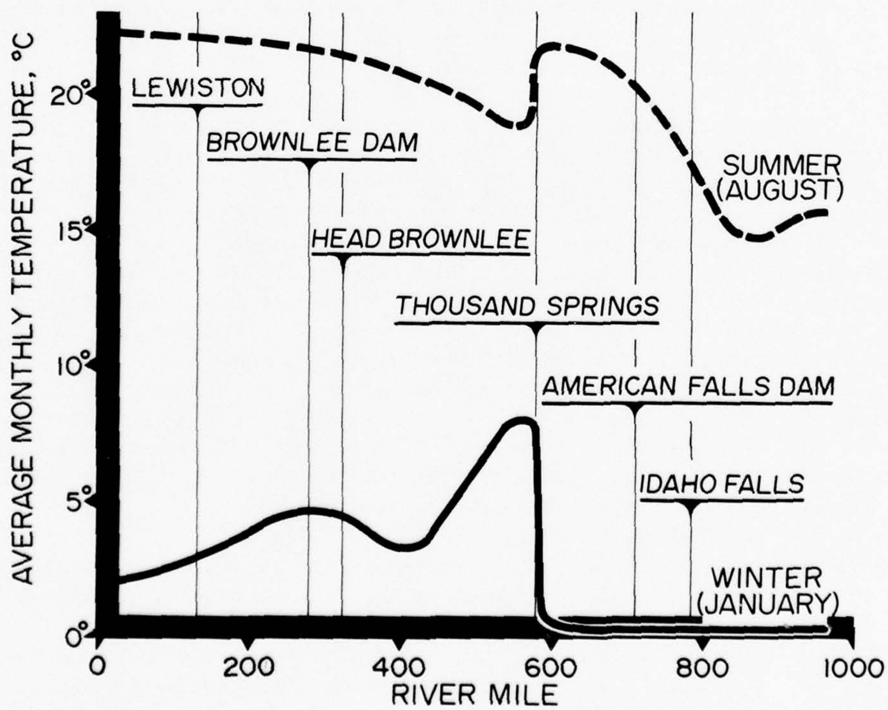


FIGURE 35. Water Temperature Profile (Generalized), Snake River.

Sediment and suspended organic material result in turbid conditions at many points in the subregion. During periods of high runoff, sediment concentrations reach objectionable levels throughout the area. Suspended organic matter is often found in heavy concentrations below food-processing sites, although this problem is receding as waste treatment advances.

The headwaters of the Upper Snake River are relatively low in mineral content (100 mg/l dissolved solids or less) and are characterized as calcium bicarbonate waters. However, dissolved solids and sodium content show marked increases downstream as a result of irrigation use. Samples collected during a low-flow period in 1965 in the reach from the Idaho-Wyoming border to Buhl, Idaho, showed a progressive increase in both dissolved solids concentration and sodium-adsorption ratio (SAR). Dissolved solids increased from about 175 to more than 400 mg/l, and SAR increased from 0.2 to 1.5. Below Buhl, the dissolved solids concentration dropped to 340 mg/l because of dilution by spring inflow. Although the alluvial materials in the area contribute somewhat to the downstream increase in mineral content, irrigation return flow is the primary contributor. The water is still satisfactory for irrigation of crops; however, in some areas treatment is required before the water can be used as a municipal or industrial water supply.

Concentrations of basic nutrients, nitrogen, and phosphorus, run high throughout much of the Snake River. Figure 36 presents a generalized total phosphate concentration profile for the Snake River. High phosphate concentrations are evident at all points in the Upper Snake River. Phosphate concentrations rise steadily throughout the subregion, then nearly triple at the head of American Falls Reservoir, where the Portneuf River deposits the wastes of Pocatello's phosphate processing. Continuing to rise rapidly through the sequence of reservoirs--American Falls, Lake Walcott, and Milner--phosphate concentrations suggest the influence of ground-water inflows that pass through natural phosphate deposits and possibily of irrigation return flows, municipal wastes, and buildup of populations of aquatic biota as well. In the Thousand Springs area, phosphates are diluted significantly although concentrations sustain levels well above those prevailing upstream from American Falls Reservoir. There is a progressive rise in nitrates in the subregion that is most marked in the Thousand Springs and American Falls areas, which suggests that ground-water inflow may be the major influence determining nitrate concentrations. Concentrations recede below Thousand Springs. Winter levels materially exceed those encountered in summer. The lower production of algae and other plants under winter conditions restricts biologic uptake of nitrates, while nitrates contained in food processing may add in some degree to concentrations.

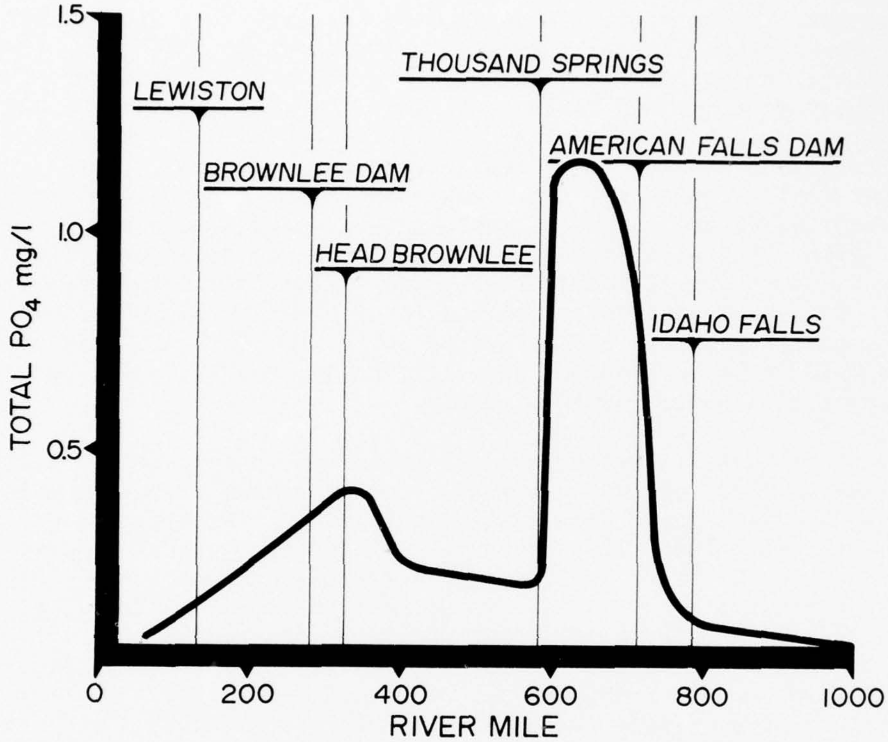


FIGURE 36. Total Phospate Profile (Generalized), Snake River.

Throughout its course of passage in the Upper Snake Subregion, the Snake River supports luxuriant growths of vegetable matter. Thick blooms of algae make the water a characteristic opaque green. Floating rafts of tangled water weeds are prevalent on the surface of the Snake and form clinging slimes where they adhere to rocks and banks. At times the growths of algae and water weeds form a complete cover over ponded water and clog irrigation canals. As these growths die and decay, they release nutrients for new growths. While excessive growths of algae and water weeds are a type of pollutant throughout much of the subregion, they also constitute an influence on other pollution indicators. Most noticeable is the influence exerted on dissolved oxygen by plant respiration and on biochemical oxygen demand. Algae are probably the principal source of biochemical oxygen demand in the subregion, far outranking domestic, municipal, and industrial wastes in this regard.

During a 1966 water quality survey in the subregion, the Federal Water Pollution Control Administration reported pesticides in dead fish found below American Falls Dam in sufficient concentrations to have killed them. Pesticide concentrations were found in the liver and viscera, where the compounds are presumed to concentrate, as well as throughout the flesh of the fish. The evidence that there is a continual, and not always sublethal, presence of pesticides in the waters passing through major agricultural areas of the subregion accumulates slowly. The techniques of pesticide analysis are difficult and costly and, because the materials have a tendency to resist mixing, water sampling will not always disclose the presence of pesticides. But the concentration of materials in the flesh of aquatic animals does provide evidence of its presence.

Tributaries

In general, tributaries in the Upper Snake Subregion are of good water quality. The lower reaches of several streams do experience serious water quality degradation. Most notable among these are the Henrys Fork, Blackfoot River, Portneuf River, and Rock Creek. Serious local water quality problems also occur in Main Drain and Aberdeen Drain.

Dissolved oxygen tends to be high in tributaries. Even Rock Creek, a small stream that receives industrial wastes from Twin Falls, maintains good dissolved oxygen levels. Main Drain and Aberdeen Drain, irrigation return streams, provide exceptions to the generally high dissolved oxygen pattern of the subregion. Even at the height of the irrigation season, oxygen levels in the drains are low in places; and in winter when a large portion of the flows is food-processing wastes, oxygen contents are

often totally depleted. Dissolved oxygen deficiencies are also suspected at points in some tributaries, although such conditions have not been completely documented.

Bacterial quality in tributaries is highly variable. In general, however, coliform densities below population centers are high enough so that the water is considered unsuitable for water-contact recreation. Very high bacterial counts have been recorded in Rock Creek, Aberdeen Drain, and Main Drain.

Sediment and suspended organic materials result in turbid conditions in many tributaries. During periods of high runoff, sediment concentrations reach objectionable levels throughout the area. Inorganic materials are visible in the waters of the Portneuf River below the J. R. Simplot phosphate-processing plant near Pocatello and result in thick, unsightly bank and bottom deposits. Irrigation returns are a summer source of localized turbidity. Silt, vegetable matter, and colloidal materials of soil or vegetable origin are often visible floating or in suspension in waters flowing through agricultural areas.

The major tributaries entering the Snake River from the north contain waters of the calcium-magnesium bicarbonate type, with smaller amounts of sodium, chloride, and sulfate. Their dissolved solids concentrations range from less than 100 to slightly more than 300 mg/l and average less than 250 mg/l. Tributaries entering the Snake River from the south are usually more mineralized and have larger percentages of sodium, chloride, and sulfate. The higher dissolved solids content of these tributaries occurs because of the geologic setting and because of extensive irrigation use. The northern tributaries flow mainly through Snake River basalts, but a larger percentage of older volcanic materials occurs in the area south of the Snake. These materials are more susceptible to solvent action, and waters flowing through them dissolve more mineral matter.

Concentrations of basic nutrients, nitrogen and phosphorus, are high in several tributaries. The Portneuf and Blackfoot Rivers consistently discharge heavy phosphate loadings to the Snake River. The largest increment of Snake River phosphate loading occurs with the entry of the Portneuf River, which carried the wastes of phosphate reduction processing plants. At least 35,000 pounds per day of phosphates enter American Falls Reservoir from the Portneuf. This amount provides the greatest share of more than 40,000 pounds per day that are carried by the Snake River. The Blackfoot Reservoir, near the head of Blackfoot River, is situated on top of a seam of phosphate-bearing earths. This has resulted in significant phosphate concentrations in the Blackfoot River. Heavy aquatic growths are also present in these streams

as a result of the high nutrient contents. Problems of nuisance aquatic growths occur in many other tributaries in the Upper Snake Subregion, but are generally localized in extent.

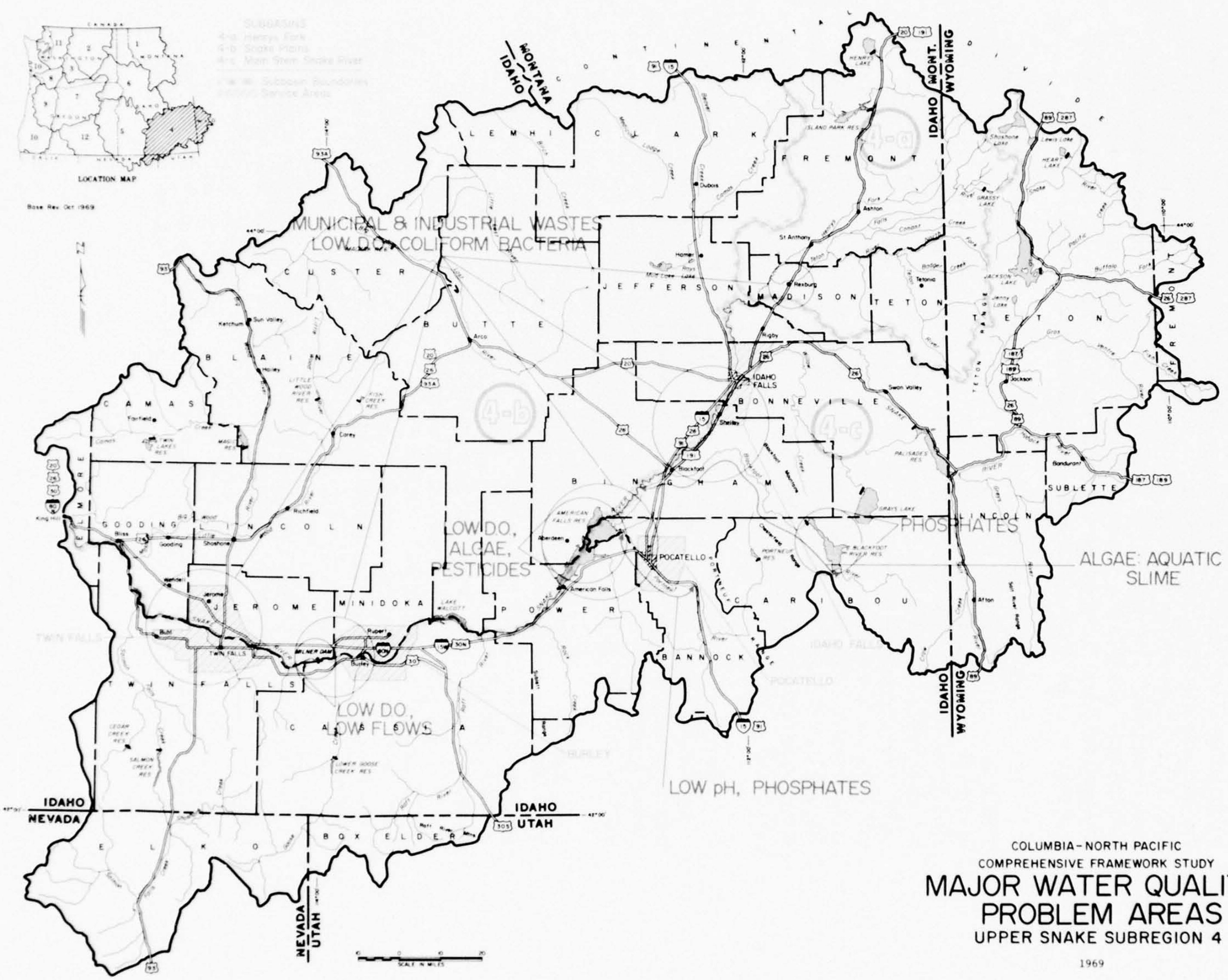
Fluoride concentrations exceed recommended drinking water standards in both ground and surface waters at a number of points. In part of the Henrys Fork system, fluoride concentrations of more than 4.0 mg/l have been reported. Big Spring Creek, Buffalo River, Warm River, and Falls River contained more than 2.0 mg/l fluoride in August of 1960. Henrys Fork, from Island Park Reservoir to the mouth, contained 1.4 to 1.8 mg/l. High fluoride concentrations have also been observed below phosphate processing plants on the Portneuf River. This problem has been mainly eliminated with the advent of partial waste treatment at the plants. For the most part, availability of alternative supplies has made the excessive fluoride content a matter of minor importance. However, fluorides are alleged to have had deleterious effects on cattle fed with forage irrigated by Portneuf River waters.

Summary of Problems

A graphical summary of water quality problem areas in the Upper Snake Subregion is presented in figure 37. Instances of significant existing pollution are fairly well defined. In most cases, pollution occurs as a result of either an insufficient degree of treatment, curtailed streamflow, or some combination of the two factors.

The combination of inadequately treated municipal and industrial wastes in winter months and depleted flows has resulted in marked pollution of lower Milner Reservoir. Three of the largest fish kills, mostly non-game species, in the United States have occurred when the reservoir was in nearly a septic condition. The Idaho Water Quality Standards require secondary treatment or the equivalent for all major waste sources in the area by 1971. However, a sustained minimum flow of 600 cfs will still be required to meet the 5.0 mg/l dissolved oxygen standard. Based on one-in-ten-year low flows expected at Minidoka gage, 140,000 acre-feet of additional water is required annually through Milner to maintain minimum streamflow during times flows would otherwise drop below 600 cfs.

American Falls Reservoir suffers from excessive aquatic growths, dissolved oxygen depressions, and high pesticide levels. Quality problems are caused by residual waste loads from upstream sources, and phosphate-processing wastes from the Pocatello area. Excessive nutrient concentrations promote nuisance-level algal



COLUMBIA-NORTH PACIFIC
COMPREHENSIVE FRAMEWORK STUDY

MAJOR WATER QUALITY PROBLEM AREAS

UPPER SNAKE SUBREGION 4

1969

FIGURE 37

growth within the reservoir, which, in addition to diurnal variation caused by normal plant respiratory processes, exerts a demand on the dissolved oxygen resource during die-off and decay periods. Impairment of reservoir use for recreation and fishery purposes has occurred. In August of 1967, for example, decomposition of dead algal cells is believed to have caused dissolved oxygen concentrations to drop to zero in some portions of the reservoir. A massive fish kill estimated at 20,000 fish resulted.

Water quality problems occur in the Snake River below Idaho Falls and in the South Fork Teton River where low dissolved oxygen and high bacterial densities result from a combination of municipal and industrial waste discharges and streamflow depletions caused by irrigation diversions. Idaho's Water Quality Standards, which call for secondary or equivalent treatment of waste discharges, will do much to alleviate these conditions. However, even with conventional secondary treatment, an annual draft-on-storage of 39,600 acre-feet in excess of irrigation diversions should be made available in the lower reaches of the South Fork Teton River to meet a 5.0 mg/l dissolved oxygen standard.

Aberdeen Drain, Main Drain, and Rock Creek suffer from low dissolved oxygen levels, high bacterial densities, and nuisance aesthetic conditions. Each of these small waterways receives large quantities of inadequately treated municipal and industrial wastes and agricultural waste waters.

The lower Portneuf River is characterized by low pH levels, high phosphate concentrations, sludge beds, and high bacterial counts. These problems result from inadequately treated domestic wastes, phosphate-processing plant wastes, and land drainage. Problems associated with pH and sludge beds are expected to be eliminated when planned waste treatment and control facilities are completed. Improved treatment is expected to decrease bacterial and phosphate levels, but will not provide the complete control necessary to maintain these parameters within desirable limits.

The Blackfoot Reservoir located on the top of a seam of phosphate bearing earth supports heavy algae growth which has not been detrimental to an extensive commercial and sports fishery for many years. Residential development along the reservoir during the past few years and foreseeable future without pollution restrictions and surveillance could be a contribution to reservoir pollution.

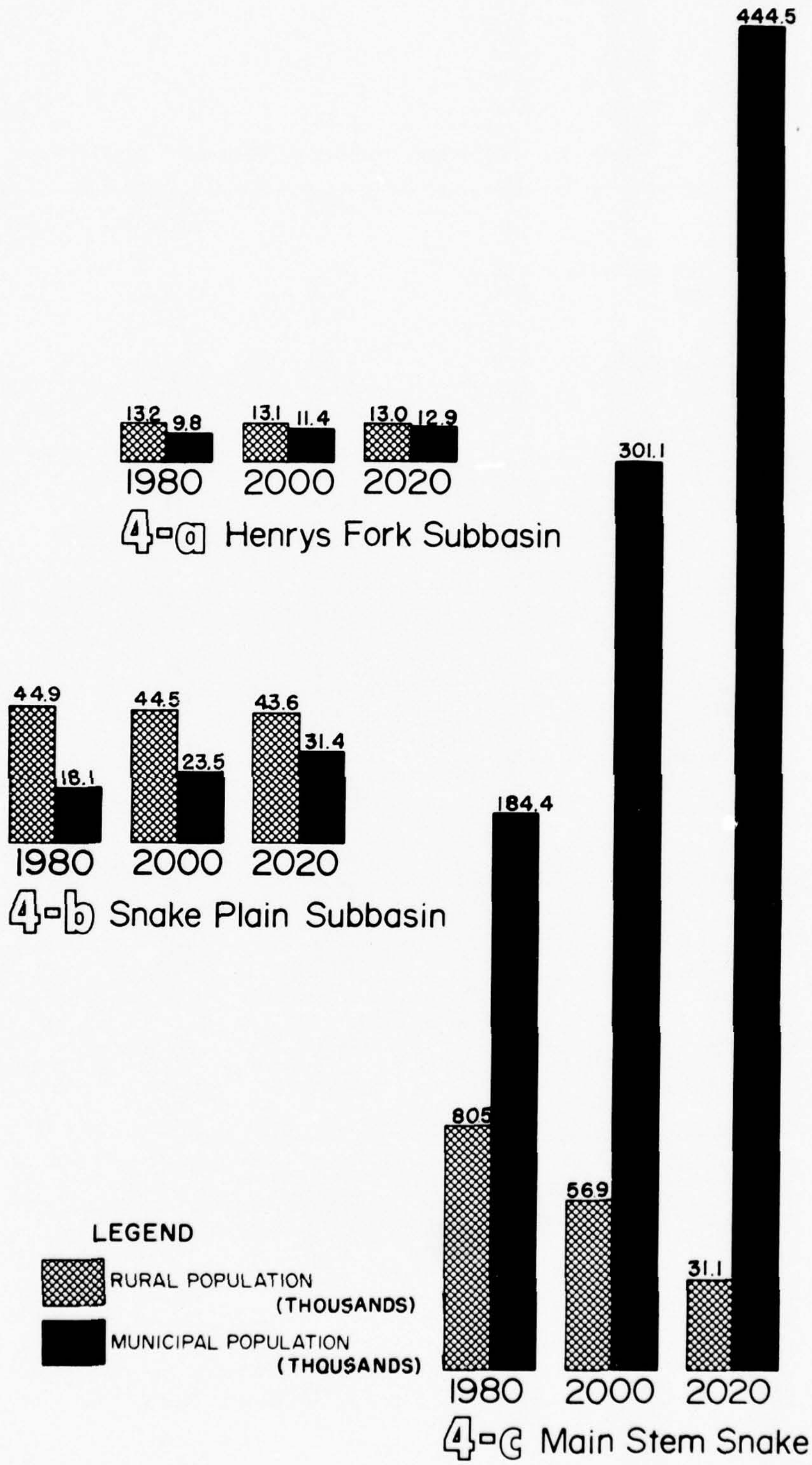


FIGURE 38. Projected Population, Subregion 4

Table 65 - Projected Population, Subregion 4 (5) 1/

	1980	2000 (thousands)	2020
Henrys Fork Subbasin	23.0	24.5	25.9
Municipal	9.8	11.4	12.9
Rural	13.2	13.1	13.0
Snake Plain Subbasin	63.0	68.0	75.0
Municipal	18.1	23.5	31.4
Rural	44.9	44.5	43.6
Main Stem Snake Subbasin	264.9	358.0	475.6
Idaho Falls Service Area	67.6	106.0	150.3
Municipal	51.6	98.0	150.3
Rural	16.0	8.0	-
Pocatello Service Area	56.7	79.0	102.1
Municipal	49.2	75.2	102.1
Rural	7.5	3.8	-
Burley Service Area	24.7	38.1	57.9
Municipal	19.1	35.3	57.9
Rural	5.6	2.8	-
Twin Falls Service Area	49.3	69.6	104.6
Municipal	40.8	65.4	104.6
Rural	8.5	4.2	-
Other	66.6	65.3	60.7
Municipal	23.7	27.2	29.6
Rural	42.9	38.1	31.1
Subtotal	264.9	358.0	475.6
Municipal	184.4	301.1	444.5
Rural	80.5	56.9	31.1
Total Subregion	350.9	450.5	576.5
Municipal	212.3	336.0	488.8
Rural	138.6	114.5	87.7

1/ Differences between totals in this table and source are due to differences in subregion boundaries. The source is based on economic boundaries and this table is based on hydrologic boundaries. The municipal population is defined as that population discharging wastes to a municipal sewerage system. The rural population is defined as the residual.

FUTURE WATER QUALITY MANAGEMENT NEEDS

Based on the projected economic development of the Upper Snake Subregion, the population is expected to increase from 302,000 in 1965 to 576,500 in 2020. This represents an increase of only 91 percent for the subregion, compared with 121 percent for the region.

Figure 38 shows the projected population growth by subbasin for the years 1980, 2000, and 2020. The projected subbasin and service area populations are presented in table 65 by municipal and rural categories. By 2020, over four-fifths of the subregion population will be located in the Main Stem Snake Subbasin, with 87 percent of the subbasin population centered in the four service areas of Idaho Falls, Pocatello, Burley, and Twin Falls. About 75 percent of the remaining population will be located in the Snake Plains Subbasin.

Future industrial growth will continue to be based on the subregion's agriculture and phosphate resources. Food processing will continue to dominate in the production of organic wastes, although it is expected that a pulp and paper plant producing a significant organic load will locate in the subregion by the end of this projection period. Inorganic phosphate-processing wastes will more than triple by 2020.

The maintenance of high quality water in the future will depend on the proper location and treatment of wastes, in conjunction with careful management of this highly regulated river system to ensure that adequate assimilative flows are available below waste discharge points.

Future Waste Production

Municipal

The projected municipal raw waste production for the Upper Snake Subregion is presented in table 66 by subbasin and service area. The population served by municipal waste collection and treatment systems is expected to increase from 43 percent in 1965 to 85 percent by the year 2020. It has been assumed that the entire populations of the four major service areas will be served by municipal collection systems by then. The four service areas are expected to account for nearly 85 percent of the subregion's municipal waste production. The Idaho Falls Service Area will produce 36 percent of the service area wastes.

Table 66 - Projected Municipal Raw Organic Waste Production 1/
Subregion 4

	1970	1980	2000	2020
		(1,000's P.E.)		
Henrys Fork Subbasin	10.6	12.2	14.2	16.1
Snake Plain Subbasin	17.7	22.6	29.4	39.2
Main Snake Subbasin	173.6	230.5	376.4	555.7
Idaho Falls Service Area	37.3	64.5	122.5	187.9
Pocatello Service Area	37.7	61.5	94.0	127.6
Burley Service Area	13.4	23.9	44.1	72.4
Twin Falls Service Area	62.6	51.0	81.8	130.8
Others	22.6	29.6	34.0	37.0
Total Subregion	201.9	265.3	420.0	611.0

1/ A factor of 1.25 was applied to the municipal population components to account for the effects of small commercial establishments and other urban activities which add to municipal waste loads.

Industrial

Projected raw organic waste productions for the major industrial categories are presented in table 67 for the years 1980, 2000, and 2020. By the end of the projection period it is expected that industries will contribute approximately 34 percent of the organic wastes produced in the subregion. Food processing will continue to be the largest waste source, contributing 93 percent of the industrial organic waste production. The phosphate-processing plants at Pocatello will continue to be a major source of inorganic materials, producing wastes containing phosphorous and fluorine compounds.

Table 67 - Projected Industrial Raw Organic Waste Production, Subregion 4 (5) (17)

	1970	1980	2000	2020
		(1,000's P.E.)		
Food Products	3,229.9	4,547.0	6,510.0	7,934.0
Pulp and Paper	0.0	-	200.0	585.0
Total	3,229.9	4,547.0	6,710.0	8,519.0

1/ Base data from FWPCA inventory of municipal and industrial wastes, Upper Snake Subregion, 1965, see table 78.

Future growth is expected to occur at existing operations for most industries. Based on that assumption, most of the food processing waste increases would occur in the Idaho Falls, Burley, and Twin Falls Service Areas. Growth in the chemical products industries would occur at the existing phosphate processing plants at Pocatello. Toxic wastes from these operations are expected to decrease in the future, however, as more stringent controls are required to meet water quality standards criteria. The projections assume that a pulp and paper plant will locate in the subregion by 2000. It is expected that such a pulp and paper operation would locate near Bliss, Idaho, since the streamflow at that point would best assimilate the wastes produced. The Snake River, near Roberts, Idaho, has also been considered as a feasible location.

Rural-Domestic

The projected rural-domestic waste production is summarized in table 68 for the years 1980, 2000, and 2020. Future rural-domestic waste production is based on the rural component of the population projections shown in table 65 and is assumed to be equal to that rural population. Rural waste production is expected to decrease slightly throughout the subregion due to population shifts from rural to urban areas and to expansion of waste collection systems within urban areas.

Table 68 - Projected Rural Domestic Raw Organic Waste Production, Subregion 4

	1970	1980	2000	2020
		(1,000's P.E.)		
Henrys Fork Subbasin	13.5	13.2	13.1	13.0
Snake Plains Subbasin	45.0	44.9	44.5	43.6
Main Snake	98.6	80.5	56.9	31.1
Total	157.1	138.6	114.5	87.7

Septic tanks and some type of subsurface drainage systems are the most likely method to be used to dispose of waste from individual residences in the future. Some alternative method should be developed to dispose of wastes in the areas now discharging septic tank effluent to the wells drilled into the ground-water aquifer. Pollution of surface water from rural-domestic sources is not expected to become a serious problem in

the future, although ground-water contamination is a threat in those areas overlying the Snake Plain aquifer.

Irrigation

Approximately 2.5 million acres of land are presently being irrigated in the subregion. By 2020 the average annual diversion requirement on new lands brought into production is expected to be only approximately 3 acre-feet per acre due to better conveyance systems and more efficient water management practices. The total 2020 diversion requirement for the subregion would therefore be about 16.5 million acre-feet annually. Irrigation of new lands at this level of efficiency will tend to minimize additional pollution from irrigation. In addition, water use on presently irrigated lands is expected to become more efficient, thus reducing pollution associated with present operations. The definition of potential water savings on presently irrigated lands was beyond the scope of the C-NP Study.

However, the potential for pollution will increase in the future as more land and storage are developed for irrigation, and the problems that have resulted from past operations will intensify unless adequate measures are initiated to prevent these problems. Some system management practices that have contributed to pollution in the past are: curtailing streamflow during fall and winter months at storage reservoirs when food-processing operations are discharging peak waste loads; diverting streamflows to irrigation canals before releases from upstream reservoirs reach the diversion point; and diverting the entire flow of the river to facilitate maintenance work on diversion structures.

Better on-farm application methods are needed in much of the subregion. Flood irrigation of hay and pasturelands in the Portneuf Basin causes water pollution that could be minimized through use of a more efficient method. If the projected diversion requirement of about 3 acre-feet per acre is to become a reality in the future, great increase in on-farm irrigation application efficiencies is a must. Also, seepage losses in existing carriage facilities must be reduced considerably.

Other Land Uses

Projections of major types of land use in the subregion by acres are shown in table 69. The projections show a decrease in land area for forest and woodland of approximately two percent by the year 2020. The wood consumption demand by the forest products

industry is projected to increase sixfold during the same period. The potential for erosion and stream damage will be greater as more intensive harvesting methods are employed by forest users. Increased sediment loads for adjacent streams may result.

Table 69 - Present and Projected Land Use, Subregion 4 (5) (8)

Land Use	1966	1980	2000	2020
		(thousand acres)		
Cropland	3,781	3,906	3,872	3,860
Irrigated	(2,410)	(2,842)	(2,944)	(3,119)
Nonirrigated	(1,371)	(1,064)	(928)	(741)
Forest	4,297	4,273	4,254	4,206
Range 1/	13,556	13,362	13,355	13,350
Other 2/	1,048	1,069	1,097	1,127
Total	22,682	22,610	22,578	22,543

1/ Does not include forest range.
2/ Includes barren land, roads, railroads, small water areas, urban and industrial areas, farmsteads, airports, etc.

Use of fertilizers on new agricultural lands bordering streams and lakes could add to nutrient levels occurring in the subregion's surface waters and could aggravate eutrophication problems that are already quite severe in some areas. Pesticides and herbicides applied to these lands could also drain into the water bodies and build up to toxic levels in higher levels of aquatic life occurring in these waters. Water quality degradation from these sources could be minimized by better management practices in the use of fertilizers, pesticides, and herbicides on all lands.

Agricultural Animals

The raw organic production by the livestock population in the subregion is expected to be equivalent to that from a population of 8,800,000 in 1980, 12,000,000 in 2000, and 15,800,000 in 2020. This would account for approximately 63 percent of the subregion's total raw organic waste production by the end of the projection period. About five percent of the wastes generated by a normally distributed animal population is estimated to eventually reach the waterways. This is not the case, however, where large numbers of animals are concentrated into small spaces as they are in feedlots and dairies. The potential for pollution from these sources is high, particularly

at those operations which are located along streambanks. Economical methods of control and disposal of feedlot wastes need to be developed and applied to all operations bordering surface waters. It may be necessary to treat wastes at locations where the potential for ground-water pollution is high.

Recreation

As the demand for water-based recreation continues to outpace population growth, the wastes resulting from these activities are expected to continue increasing at a rapid rate. Construction and expansion of adequate waste disposal facilities at recreation areas must keep pace with the increased recreational use to prevent water pollution from this source. The following summary of projected raw waste production by recreation activities gives an indication of the amount of future construction that will be required.

Year	Population Equivalents 1/
1970	90,000
1980	122,500
2000	225,000
2020	414,500

Many of the subregion's lakes and reservoirs that now receive heavy recreational use will be used to their full potential by the end of the projection period. Jackson Lake, Palisades Reservoir, and American Falls Reservoir are expected to receive particularly heavy use by then.

Other Factors Influencing Quality

Perhaps the greatest threat to the subregion's water quality is the unsightly algal growths that now occur annually on much of the subregion's surface waters. The growths are stimulated by nutrients originating from phosphate deposits, from agricultural wastewaters, from municipal sewage, and from wastes generated at the phosphate processing plants near Pocatello. These growths flourish in impounded waters where water temperatures are maximum and water circulation is minimum. Construction of storage reservoirs to meet future water needs is expected to add to this problem, not only in the impoundment itself, but

1/ Source: Bureau of Outdoor Recreation and U.S.D.A. Forest Service Projections for total man recreation days (TMRD).

downstream as well. Areas where extensive problems are expected are Blackfoot Reservoir, American Falls Reservoir, and Milner Reservoir. Problems now experienced on other water bodies are expected to intensify in the future.

While erosion and sediment transport problems are not as severe in the Upper Snake Subregion as they are in other areas of the region, there is a need for improved land management practices to hold the contribution from these sources to an absolute minimum. In particular, additional erosion control is needed in Marsh Creek Valley of the Portneuf River drainage to reduce the sediment load that has been contributed by this area in the past.

Although hydropower production is not a major water user and has not been associated with subregion water quality degradation in the past, the potential for adverse water quality effects is great at installations that are not operated to minimize these effects. As hydropower is used more and more to meet peak loads, greater fluctuations in flows will result with an accompanying lowering of the waste assimilative capacity of the stream during low flow cycles. Damming a free-flowing stream for power generating purposes may degrade water quality, both within the pool and the stream below. Power withdrawals from lower level intakes are deficient in dissolved oxygen at times. An impoundment will alter the water temperature regime that existed under free-flowing conditions; however, this may result in an improved water temperature regime.

Quality Goals

Quality goals are based on state water quality standards criteria established for the subregion waters. Water quality standards for Wyoming, Idaho, Utah, and Nevada, apply to portions of the subregion; however, the standards adopted by Utah and Nevada are of minor concern to maintenance of water quality in the Upper Snake drainage since the subregion streams in these states are small headwater tributaries in areas having very little pollution potential. The standards of all four states contain two provisions that are critical to the maintenance of high quality water: one, the antidegradation provision which ensures that waters whose existing quality is better than the established standards will be maintained at that high quality; and two, the provision that the highest and best practicable treatment under existing technology will be applied to all waste discharges.

Waters in Idaho are protected for domestic and industrial water supply, irrigation, livestock watering, propagation of salmonid fishes, and recreation. The critieria established to

protect these uses will not allow waste discharges that will cause the dissolved oxygen to be less than 75 percent saturation at seasonal low, or less than 100 percent in spawning areas during spawning, hatching, and fry stages of salmonid fishes; the temperature to exceed 68°F.; objectionable turbidity; and the average coliform concentrations to exceed 240 per 100 ml along the shores of lakes and 50 per 100 ml in the main body of a lake or stream.

Waters in Wyoming are protected for municipal water supply, fish and wildlife propagation, agriculture, body contact recreation, aesthetics, and waste assimilation. Recreational use is expected to dominate in the future; little increase in municipal water supply and irrigation water use is anticipated. Standards criteria established to maintain acceptable water quality to permit these uses will not allow activities or waste discharges that will cause: a turbidity increase of more than 15 units; dissolved oxygen concentrations of less than 6 parts per million; a temperature increase of more than 2°F. (1.1°C.) where natural temperatures do not exceed 70°F. (21.1°C.), nor an increase of more than 4°F. (2.2°C.) up to a maximum of 78°F. (25.5°C.) where natural temperatures exceed 70°F. (21.1°C.); the hydrogen-ion concentration to fall outside the range of 6.5 to 8.5; organisms of the fecal coliform group to exceed 240 per 100 ml as a geometric mean of the last five consecutive samples, nor exceed 750 per 100 ml in any one sample. In addition, the waters shall be essentially free from floating or settleable solids; substances causing taste, odor, or color; toxic substances; and radioactive materials.

Waters in the Nevada portion of the subregion are protected for fish and wildlife, aesthetics, wastewater assimilation, irrigation, and stock-watering uses. The criteria established to protect these uses vary appreciably by stream and reach, but in general they will not allow activities or waste discharges that cause dissolved oxygen concentrations to be less than 7.5 mg/l; biochemical oxygen demand to exceed 10 mg/l; temperatures to exceed 80.6°F. (27°C.) in summer or 57.2°F. (14°C.) in winter; hydrogen-ion concentrations to fall outside the range of 6.5 to 9.5; chloride concentrations to exceed 15 mg/l; phosphate concentrations to exceed 0.1 mg/l; nitrate concentrations to exceed 1.0 mg/l; or total dissolved solids concentrations to exceed 250 mg/l. In addition, the waters shall be free from materials which produce objectionable taste and odor; turbidity and color; visible floating oil; floating solids and debris; bottom deposits; or contaminants and radionuclides which exceed the Public Health Service 1962 Drinking Water Standards.

Waters in Utah are designated as class "C" to be used for domestic and industrial water supply; livestock water supply;

irrigation water supply; propagation and perpetuation of fish and other aquatic life and wildlife; and recreational uses. The criteria established to protect these uses prohibits discharges of toxic materials or wastes that will cause slicks; floating solids and suspended solids; chemical and radiological content to exceed the Public Health Service 1962 Drinking Water Standards; hydrogen-ion concentrations to exceed the range of 6.5 to 8.5; monthly arithmetical mean coliform density to exceed 5,000 per 100 ml; monthly arithmetical mean biochemical oxygen demand to exceed 5 mg/l or dissolved oxygen concentrations to be less than 5.5 mg/l.

The above uses and criteria apply generally to the waters of the subregion, but water quality standards documents should be consulted for information on specific waters. A complete set of each State's water quality standards is available upon request from the following State agencies: Idaho Department of Health; Wyoming Department of Public Health; Nevada Department of Health and Welfare; and Utah State Department of Health.

MEANS TO SATISFY DEMANDS

Controlling pollution in the Upper Snake Subregion to provide high quality water to adequately serve the river system's functions will require a coordinated program of waste reduction, flow regulation, application of waste-controlling techniques, and development of a system of cooperative management of the watershed for pollution control.

Waste Treatment

Future Waste Discharges

Future water quality management in the subregion is largely dependent on providing adequate municipal and industrial waste treatment. For purposes of this study, it is assumed that wastes will be treated to remove 85 percent of the organic material by 1980, and that treatment will be upgraded to 90 percent BOD removal by 2000. In some cases it may be necessary to provide higher degrees of waste treatment for removal of residual organic materials and nutrients.

Based on the above treatment levels and raw waste projections presented earlier, the projected municipal waste loadings to be discharged to waters of each subbasin are shown in table 70. The industrial waste loadings for major industrial categories are presented in table 71. The total municipal and industrial organic waste loading is expected to be 721,800 PE in 1980; 713,000 PE in 2000; and 913,000 PE in 2020.

Table 70 - Projected Municipal Organic Waste Discharges, Subregion 4

	1980	2000	2020
		(1,000's P.E.)	
Henrys Fork Subbasin	1.8	1.4	1.6
Snake Plain Subbasin	3.4	2.9	3.9
Main Snake Subbasin	34.6	37.7	55.6
Idaho Falls Service Area	9.7	12.3	18.8
Pocatello Service Area	9.2	9.4	12.8
Burley Service Area	3.6	4.4	7.2
Twin Falls Service Area	7.7	8.2	13.1
Others	4.4	3.4	3.7
Total Subregion	39.8	42.0	61.1

Table 71 - Projected Industrial Organic Waste Discharges, Subregion 4

	1980	2000	2020
		(1,000's P.E.)	
Food Products	682.0	651.0	793.4
Pulp and Paper	-	20.0	58.5
Total	682.0	671.0	851.9

By 2020, over 90 percent of the municipal waste load is expected to originate in the Main Snake Subbasin, mostly from the major service areas of Idaho Falls, Pocatello, Burley, and Twin Falls. The remaining municipal waste load will be scattered among the numerous small communities in the Henrys Fork and Snake Plain Subbasins.

The largest organic loads, representing 87 percent of the total municipal and industrial loads produced by 2020, will stem from food processing endeavors. The major part of the food processing load is generated at potato plants located in the Henrys Fork and Main Snake Subbasins. The largest concentration of potato processors are located in the Burley Service Area, where substantial growth in the industry is expected.

The inorganic wastes discharged by phosphate processing plants in the Pocatello Service Area are expected to be eliminated in the future through treatment and process controls.

The projections assume that a pulp and paper plant will locate in the subregion by 2000 and by 2020 will be discharging an organic waste load equivalent to a population of 58,000. It is assumed this plant will locate in the Snake Plain Subbasin in the vicinity of Bliss, Idaho.

Treatment Costs

Curves showing estimated costs of constructing (total capital) and operating (annual operation and maintenance) municipal sewage treatment plants for various treatment levels are presented in the "Means to Satisfy Demands" section of the Regional Summary.

Other Pollution Control Practices

Adequate treatment of municipal and industrial wastes, coupled with the maintenance of base streamflows to assimilate residual and noncollectable wastes, will do much toward meeting the water quality standards criteria established for the subregion. However, many water quality problems are caused by other practices that must be controlled to ensure that water quality standards are maintained in the future.

The importance of protecting the quality of the Snake Plain Aquifer cannot be over-emphasized. In addition to the ever-present threat of pollution from waste sources above the permeable strata overlying the aquifer, the ground-water quality is seriously threatened by discharges of radioactive wastes, septic tank effluent, storm drainage, and irrigation waste water to wells drilled into the aquifer. Alternative means of disposing of radioactive wastes are recommended in a report on a FWPCA study of the waste disposal practices at NRTS. Lagooning and land disposal of these wastes would have a lesser adverse effect on the environment. The study now underway to evaluate the effects of discharging septic tanks, storm drainage, and agricultural wastewaters directly to the ground water will indicate the controls that should be placed on these discharges. It may be necessary to construct sewage collection systems to replace septic tanks in some areas. Holding or settling ponds may be required to minimize the effects of agricultural wastewaters and storm drainage. It may be necessary to prohibit discharging these wastes to wells.

Estimates of future irrigation requirements are based on improved conveyance and distribution systems, together with more efficient on-farm application practices. Institution of these practices will reduce the amount of dissolved and suspended materials reaching the subregion's waters through irrigation

returns but materials in sufficient quantities to cause water quality degradation in receiving waters are still expected. Interception and reuse of these returns would be the best method of control. Where this is not practicable, it may be necessary to apply treatment and/or other controls to reduce the impact of these returns in critical reaches. Settling basins may be required to reduce the amount of suspended materials carried by all agricultural wastewaters before they are released to surface waters.

Controls to minimize land runoff of sediments, nutrients, and commercial toxicants are essential for maintenance of water quality. Soil stabilizing practices presently promoted for agriculture should be extended to include logging practices, construction channel improvements, and other practices that bear upon deposition of soil in water bodies. Control of fertilizers and commercial toxicants through development of optimal application practices and careful controls is essential, in view of the increasing intensity of use of these materials.

The large animal population in the subregion, in particular those animals in large feedlots along surface waters, represents one of the largest sources of organic wastes in the subregion. Fences and simple retaining structures between the animal habitat and watercourses should be provided in order to prevent bank erosion and to limit direct surface drainage so that wastes may decompose through soil processes. At some places it may be preferable to collect the waste from cattle-holding facilities to be distributed to the land as a fertilizer, or for treatment before discharging to watercourses.

Recreation areas will be increasing in numbers, size, and intensity throughout the subregion. Sewage disposal systems adequate to cope with weekend loads from use by thousands will be needed in many recreation areas. Facilities for collection and pickup of litter and garbage must also be made available, since these things may add to the waterborne debris load. Restrictions on motorboats on heavily used lakes may be necessary to keep oil and gas pollution at a minimum. Sanitary waste treatment or holding facilities should be required on all watercraft. Facilities to receive the contents of boat holding tanks should be available at all launching sites.

Detailed studies of the algae problem are needed to better define the controls necessary to alleviate present conditions The sources of nutrients and their point of entry into surface waters must be known to determine the potential for algae reduction through nutrient control.

Minimum flow needs for water quality control must be considered in planning future developments, or in altering the operation at existing sites. Future base power demands will be met with thermal installations and the hydroplants will be used to meet peak loads to the extent possible. Facilities to treat cooling water will be required at all thermal plants in the sub-region to prevent the discharge of excess heat to surface waters. Re-regulating reservoirs should be constructed below some hydro installations used to meet peak power loads.

Minimum Flow Requirements

Since waste treatment alone does not provide an economic solution for complete removal of contaminants from waste waters and waste discharges from nonpoint sources, a certain amount of streamflow is necessary for dilution and assimilation of residual wastes. The minimum flow requirement for assimilation of wastes is related to a number of factors, including the strength and deoxygenation capacity of the wastes; and the temperature, reaeration capacity, elevation, and minimum allowable dissolved oxygen for the stream.

A set of generalized curves showing minimum flow requirements for raw waste loadings subjected to various treatment levels is presented in figures 39 and 40. These figures give only approximate requirements based on dissolved oxygen standards criteria for small to middle-sized communities located on tributary streams. The value "f" is the ratio of the reaeration capacity of the stream to the oxidation rate of the waste contributing to the biochemical oxygen demand. Figure 39 shows the flows required at various elevations to meet Idaho's dissolved oxygen criterion at seasonal low. Figure 40 gives the flows necessary to maintain Wyoming's dissolved oxygen standard. Figure 39 and the first curve in figure 40 are based on the assumption that the standards criteria have been exceeded in the past on the streams in question. In those locations where existing quality is above the minimum established in the water quality standards documents, the antidegradation provision applies. The second curve in figure 40 presents estimated minimum flow needs for various waste treatment levels at locations where this provision applies. The areas to which the curves apply are delineated in figure 41.

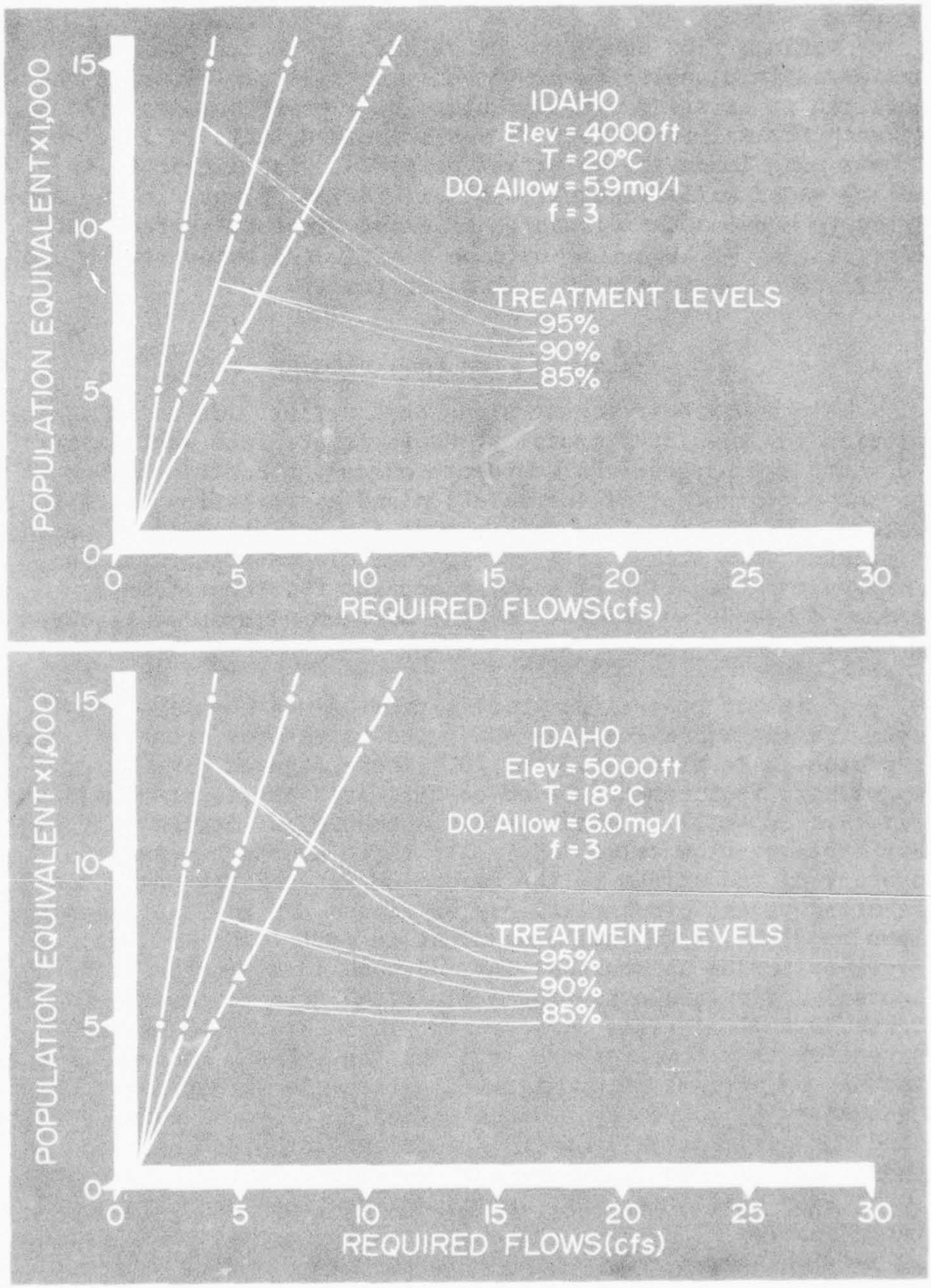


FIGURE 39. Minimum Flow Needs to Maintain Idaho Dissolved Oxygen Standards Criteria

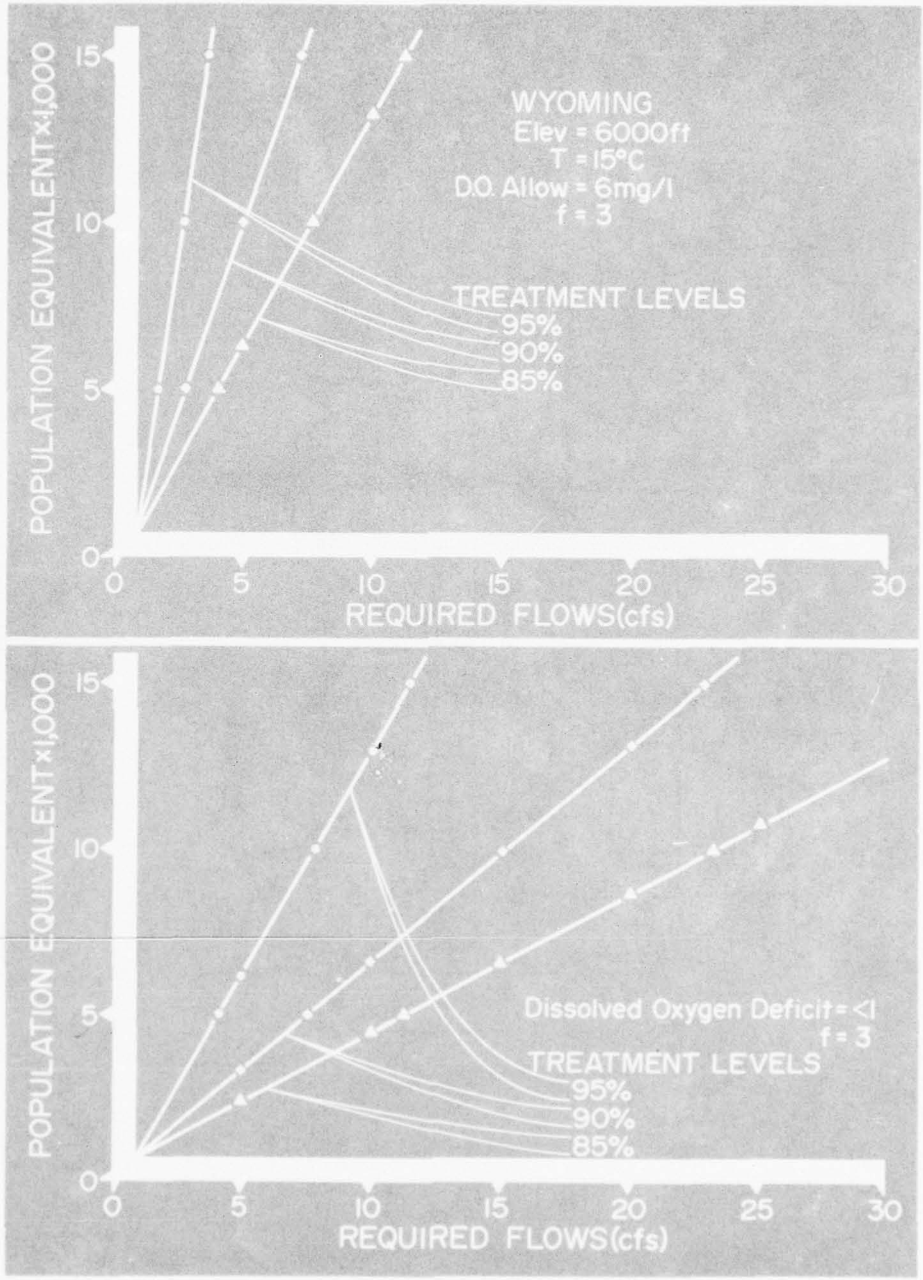
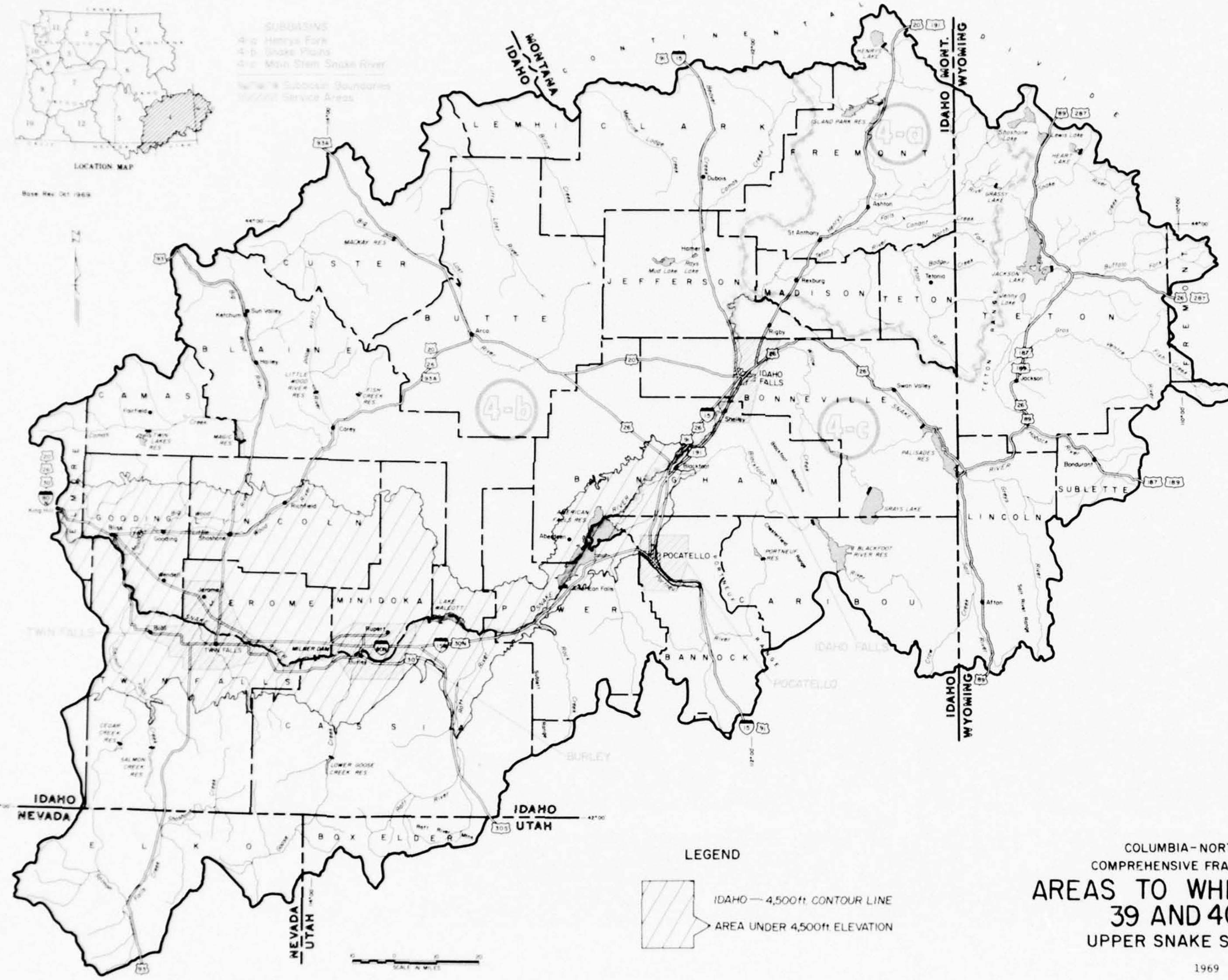


FIGURE 40. Minimum Flow Needs to Maintain Wyoming Dissolved Oxygen Standards Criteria



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AREAS TO WHICH FIGURES 39 AND 40 APPLY

UPPER SNAKE SUBREGION 4

1969

FIGURE 41

All curves are necessarily based on very broad assumptions and are intended to give an indication of what is needed to maintain dissolved oxygen standards only. Other standards criteria will control in many cases and will very likely require that flows two or three times greater than those shown in the figures be provided. For example, in some areas it has been necessary to provide a 20/1 streamflow/effluent discharge dilution ratio to prevent slimes and other aesthetically displeasing conditions occurring below discharges of sewage accorded secondary treatment. Based on per capita waste flows expected in 2020, a streamflow of 54 cfs would be required to provide this diluation to secondary effluent from a community of 10,000 persons. In contrast, a flow of only 25 cfs would be required to meet a dissolved oxygen standard which allows a deficit of 1.0 mg/l.

In addition to the general curves discussed above that apply primarily to discharges from small municipalities to tributary streams, specific flow requirements to meet dissolved oxygen standards criteria have been computed for stream reaches below large industrial and/or municipal waste discharges. Computed requirements are discussed by reach in the following paragraphs.

Main Stem Snake River

Flow needs by month to maintain dissolved oxygen standards criteria under present and projected waste loadings have been determined for the Snake River through Milner Reservoir, at Idaho Falls, at Blackfoot, at the mouth of Rock Creek below Twin Falls, and near Bliss. Curves of flow needs in cfs versus projection year for 85, 90, and 95 percent treatment levels have been developed for each reach and are presented in figures 42 through 46. The curves represent the flow needs for the month having the largest requirement. The maximum month varies by type of waste loading and location, although usually it is September or October, when peak potato-processing wastes are discharged. The annual distribution of required flows, by month, expressed as percentages of the maximum month requirement, is also shown for each reach for the year 2020. The annual distribution of flow needs for 2020 can be used to approximate the distribution for interim years. Thus, the figures can be used to determine a flow need associated with a given treatment level for any month of the projection period. Also, the average flow requirement for any year can be derived by applying the percentage given in the note on each figure to the maximum month requirement for the year in question.

Flow needs in the Snake River reaches are based primarily on potato-processing waste loads. Because of pollution problems in Milner Reservoir and the lack of flows to alleviate the problems, it was assumed that no increase in potato-processing

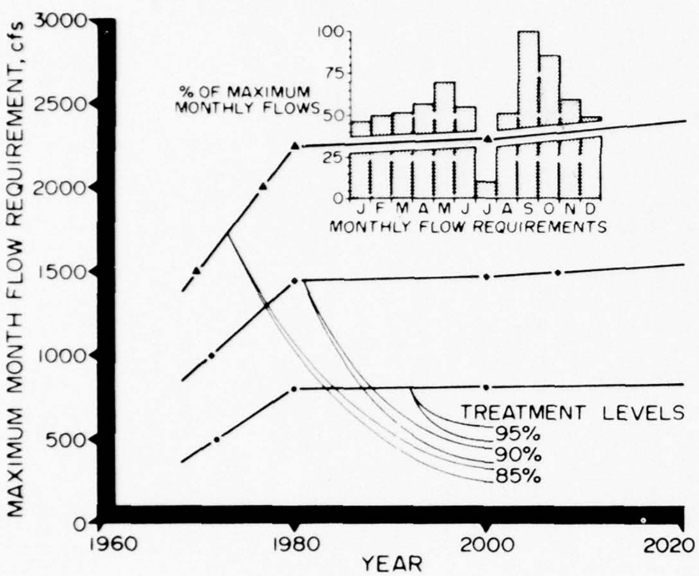


FIGURE 42. Minimum Flow Needs for Water Quality Control, Snake River through Milner Reservoir
Note: Average annual flow is 58 percent of the maximum month flow.

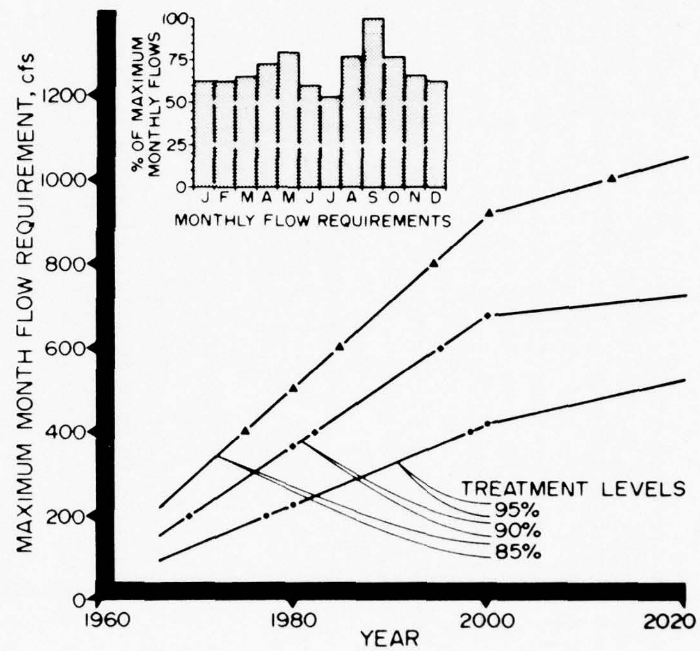


FIGURE 43. Minimum Flow Needs for Water Quality Control, Snake River at Idaho Falls
Note: Average annual flow is 73 percent of the maximum month flow.

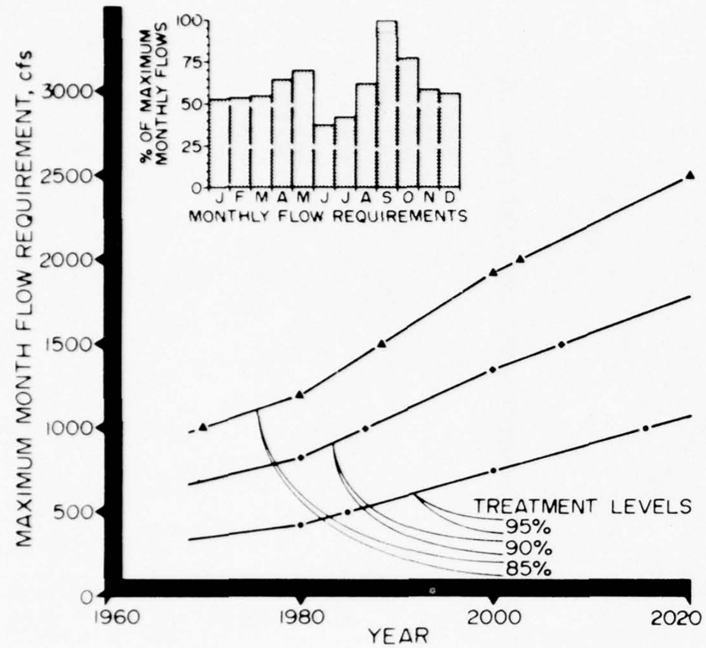


FIGURE 44. Minimum Flow Needs for Water Quality Control, Snake River at Blackfoot

Note: Average annual flow is 63 percent of the maximum month flow.

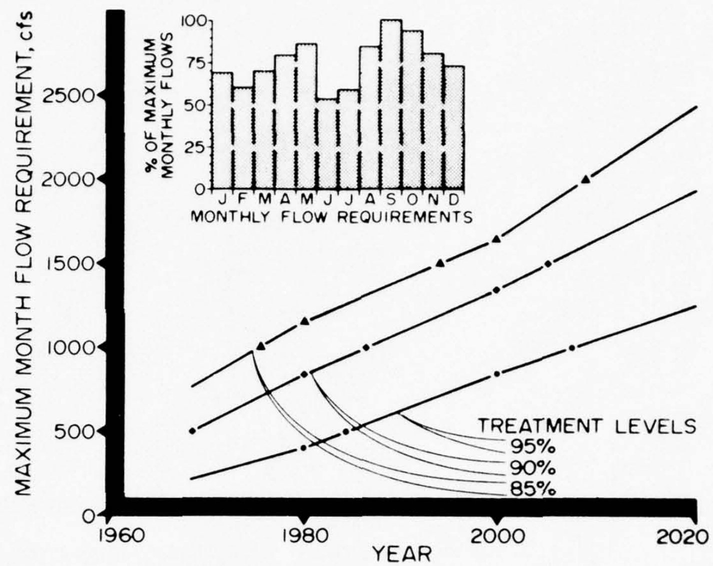


FIGURE 45. Minimum Flow Needs for Water Quality Control, Snake River at Mouth of Rock Creek

Note: Average annual flow is 75 percent of the maximum month flow.

waste discharges to Milner pool would be allowed after 1980. It was assumed that this growth would take place in Buhl and Twin Falls. Also, it was assumed that the sugar beet processing wastes now being discharged near Twin Falls would be discontinued by 2000, reflecting available in-plant controls that eliminate the need for discharging virtually any waste.

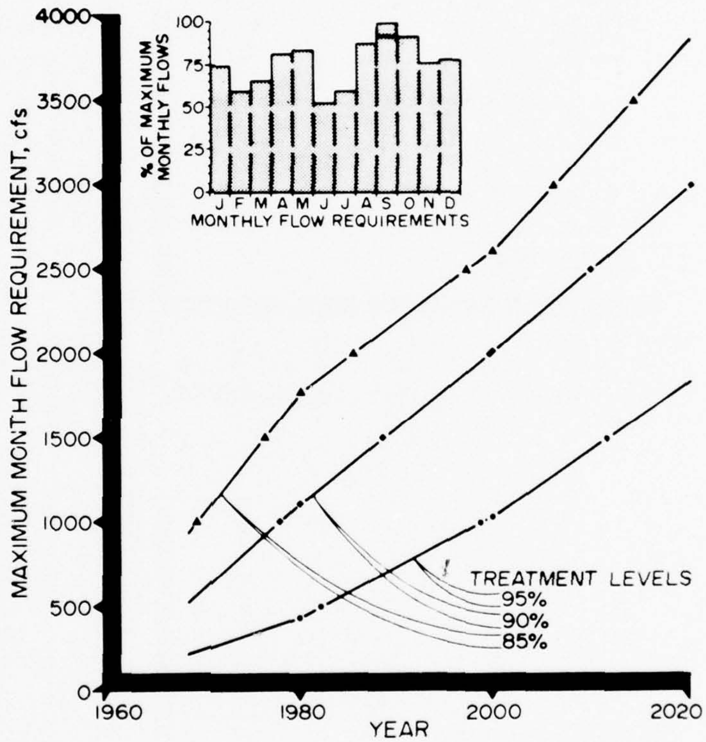


FIGURE 46. Minimum Flow Needs for Water Quality Control, Snake River near Bliss

Note: Average annual flow is 77 percent of the maximum month flow.

Henrys Fork River

Figures 47 and 48 contain curves of flow needs by years and treatment levels for the South Fork Teton River at Rexburg, and for the Henrys Fork River below the mouth of the South Fork Teton River. Flow needs are based primarily on potato plant

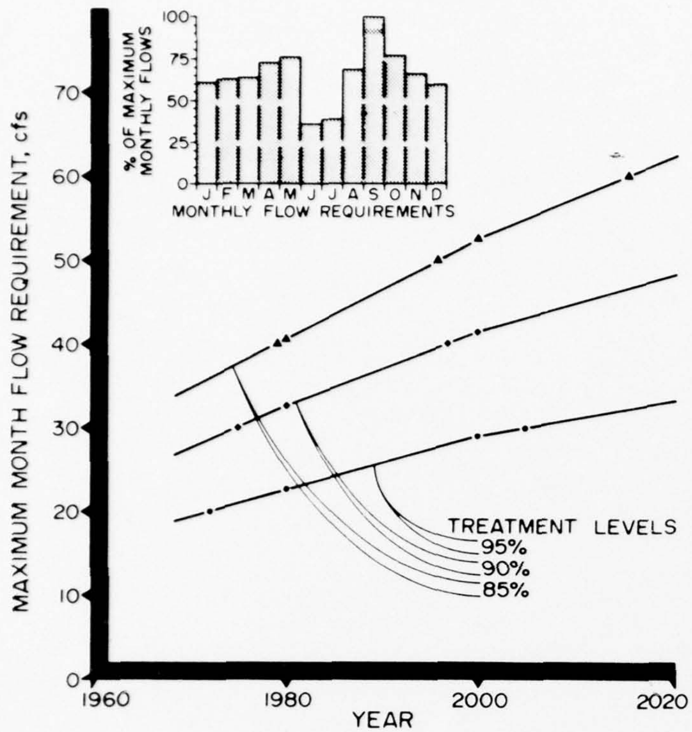


FIGURE 47. Minimum Flow Needs for Water Quality Control, South Fork Teton at Rexburg
Note: Average annual flow is 67 percent of the maximum month flow.

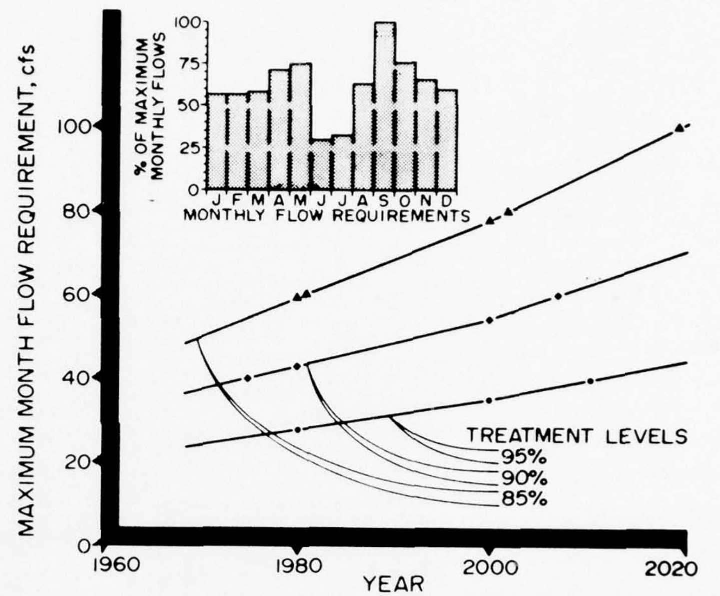


FIGURE 48. Minimum Flow Needs for Water Quality Control, Henrys Fork below South Fork Teton
Note: Average annual flow is 65 percent of the maximum month flow.

loadings at St. Anthony and Rexburg. Transportation of wastes from Rexburg to the Henrys Fork River has been considered a competitive alternative to maintaining minimum flows in the South Fork Teton River.

Management Practices

The management of the water resources of the Upper Snake is an important factor in preserving water quality of the streams and rivers. Detailed planning and adequate financing are required so as to prevent potential water pollution which would otherwise result from increasing waste loadings. Water quality must be considered in the planning and operation of all new reservoirs and in changes made in present operating procedures.

Minimum flow needs for water quality control must be considered in planning future hydropower developments, or in altering the operation at existing sites. Future base power demands will be met with thermal installations and the hydroplants will be used to meet peak loads to the extent possible. Facilities to treat cooling water will be required at all thermal plants in the subregion to prevent the discharge of excess heat to surface waters. Reregulation reservoirs should be constructed below hydro installations used to meet peak power loads.

LOCATION MAP

SUBREGION 5

SUBREGION 5

CENTRAL SNAKE

INTRODUCTION

The Central Snake is the largest subregion in the Columbia-North Pacific Region, containing 36,825 square miles in the states of Idaho, Oregon, and Nevada. The largest portion of the subregion lies within the Snake River Plateau province. The area is bounded on the northeast by the Northern Rocky Mountains, on the northwest by the Blue Mountains, and on the west and southwest by the Great Basin.

The climate is similar to that of other subregions east of the Cascade Range--hot, dry summers and cool winters during which most of the precipitation falls. Average annual temperatures range from 40° to 50°F. (4.4° to 10.0°C.), and extreme temperatures range from -49° to 117°F. (-45 to 47.2°C.). The plateau receives only 6 to 15 inches of precipitation a year, while the mountains average as much as 40 inches. Much of the precipitation at higher elevations is in the form of snow, providing water to streams until June. Summer droughts are a common characteristic, with precipitation averaging less than an inch throughout much of the subregion. The growing season ranges from 160 days in the lower valleys to less than 60 days in the mountain valleys.

The economy is largely based on agricultural production and processing. The principal crops grown and processed are potatoes and sugar beets. The processing of livestock, dairy, and poultry products is also of importance. There is a limited amount of manufacturing in the Boise area.

The population of the Central Snake Subregion, which was about 268,500 in 1965, is concentrated in the area extending from Boise into eastern Oregon. As a result, large areas in the subregion are very sparsely populated.

The Central Snake Subregion (figure 49) is divided into the Payette-Weiser, Boise, and Snake River and Other Tributaries Subbasins. The major service areas are the Ontario-Payette and Boise areas.

PRESENT STATUS

The waste input and water quality problems of the subregion are closely related to the economic base of irrigation, agriculture, and food-processing. Food processors are the major source of industrial organic wastes and also account for more than three-fourths of the organic waste loading treated in municipal systems. A graphical summary of the municipal and industrial waste production and discharge is presented in figure 49. Agricultural animal waste drainages from cattle feedlots and grazing areas, and irrigation return flows are also major pollution sources. In addition, storage of water for irrigation and irrigation diversions contribute to pollution problems in several areas where waste treatment is practiced by reducing the waste assimilative capacity of water bodies.

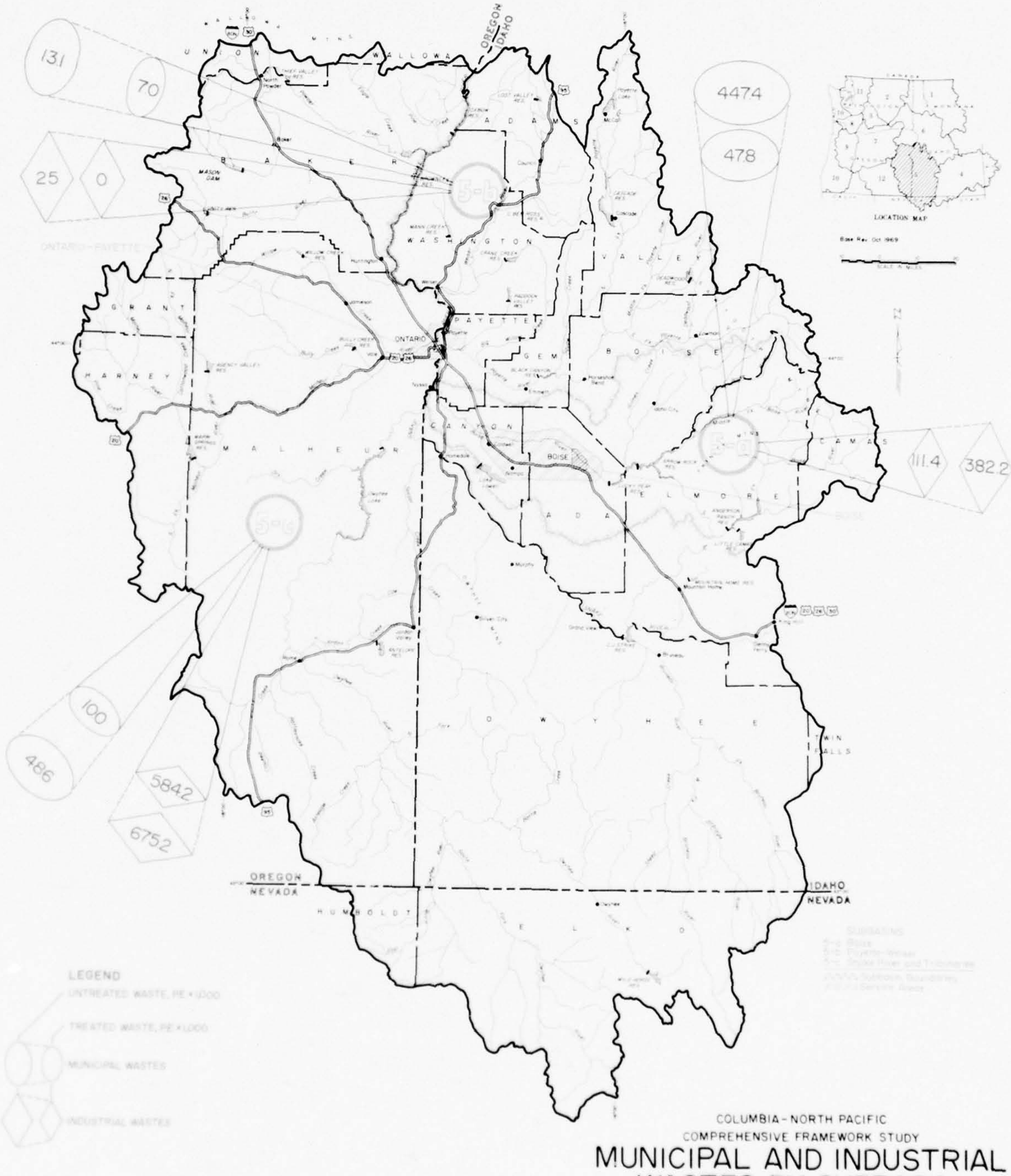
The quality of waters of the Central Snake and its tributaries is generally suitable for most uses. However, serious pollution problems exist in several areas. The most widespread problems are prolific algal blooms and high coliform bacterial densities. Localized areas of low dissolved oxygen, high suspended sediment, and dissolved solids also occur.

Stream Characteristics

Upstream contributions to the Central Snake Subregion consist solely of the flow at King Hill. This inflow is primarily ground-water effluent from the Thousand Springs area, augmented at times by sizable, uncontrolled flood flows. To this inflow is added the runoff from several major tributaries, which include the Bruneau, Boise, Owyhee, Malheur, Payette, Weiser, Powder, and Burnt Rivers. The average annual runoff is about 8,600 cfs at King Hill and 16,300 cfs at Oxbow, an increase of 7,700 cfs within the subregion.

Surface-Water Hydrology

The streamflow regimen of the Snake River and its tributaries is characterized by high flows from early spring through the first part of the summer and low flows from late summer through the winter. This is typical of streams that receive a large part of their annual runoff from melting snow. In general, the maximum floods for the year occur during the snowmelt period between March and the last of June. The runoff of the Snake River at King Hill is relatively uniform throughout the year, since about 70 percent of the average annual runoff at this point comes from a group of springs between Milner and King Hill. Flows of



COLUMBIA-NORTH PACIFIC
COMPREHENSIVE FRAMEWORK STUDY

MUNICIPAL AND INDUSTRIAL WASTES BY SUBBASIN

CENTRAL SNAKE SUBREGION 5

1969

FIGURE 49

Table 72 - Average Monthly Discharge, Subregion 5 (12)

	Jan.	Feb.	Mar.	April	May	June	July CFS	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
Bruneau River near Hot Springs, Idaho	148	180	278	788	1,104	843	244	101	80	98	117	127	342
Owyhee River below Owyhee Dam, Oregon	8	36	222	1,219	656	221	225	210	164	43	8	8	252
Boise River near Boise, Idaho	375	1,302	978	4,168	5,825	5,199	4,719	4,251	3,258	815	319	177	2,619
Boise River at Notus, Idaho	947	878	1,413	2,248	1,768	990	361	373	481	677	722	669	960
Malheur River near Hope, Oregon	82	338	406	601	273	37	50	24	27	25	20	57	160
Payette River near Horseshoe Bend, Ida.	1,170	1,201	1,661	4,281	7,299	7,405	3,619	3,411	2,807	1,555	1,124	1,244	3,070
Payette River near Payette, Idaho	1,656	1,914	2,455	4,690	6,483	6,047	1,627	1,432	1,524	1,490	1,510	1,681	2,707
Weiser River near Weiser, Idaho	637	1,155	2,168	2,745	2,451	1,270	281	203	158	156	266	581	1,004
Snake River at Weiser, Idaho	1[illegible],534	15,459	18,694	23,831	21,479	18,065	10,399	10,173	11,413	12,898	12,383	12,763	15,074
Burnt River near Hereford, Oregon	21	25	73	277	164	109	88	92	64	36	16	19	82
Powder River near Robinette, Oregon	246	374	628	1,108	1,378	1,271	362	110	108	151	192	223	512
Snake River below Pine Creek at Oxbow, Oregon	19,547	19,907	22,047	26,464	18,864	17,071	7,262	9,853	11,972	13,399	13,966	16,166	16,338

practically every major tributary stream are affected by storage for irrigation and by irrigation diversions which reduce the summer flows and, to some extent, increase the winter flows through return of irrigation water. Table 72 summarizes mean monthly discharge data for selected stations.

Critical low-flow conditions occur mainly in late summer and through the winter. This is also the period of maximum industrial waste production. Occurrence of low flows is also a function of the management regimen of the subregion's waters. Low flows are often the result of withholding water to build up storage for irrigation or of the actual diversion to the fields of a significant part of a stream. One-in-ten-year low flow is the selected recurrence frequency to predict critical low flows. These data for selected stations are summarized in table 73. The most serious quality degradation associated with reduction of flows is in the lower Boise River.

Table 73 - One-in-Ten-Year Low Flows, Subregion 5 (12)

Stream and Location	One-in-Ten-Year Low Flows 1/ (cfs)
Bruneau River near Hot Springs, Idaho	52
Owyhee River below Owyhee Dam, Oregon	8
Boise River near Boise, Idaho	<40
Boise River at Notus, Idaho	110
Malheur River near Hope, Oregon	32
Payette River near Horseshoe Bend, Idaho	680
Payette River near Payette, Idaho	960
Weiser River near Weiser, Idaho	60
Snake River at Weiser, Idaho	8,400
Burnt River near Herford, Oregon	<3
Powder River near Robinette, Oregon	42
Snake River at Oxbow, Oregon	5,200

1/ Period of 1 month.

Impoundments and Stream Regulation

There are 36 existing structures which have storage capacities of 5,000 acre-feet or more in the Central Snake Subregion. Active storage amounts to about 4.6 million acre-feet. Development has been directed largely to irrigation. The high level of irrigation storage capacity is accompanied by corresponding diversion capacities. Considerable alteration has been imposed on the flow pattern, with two significant effects: winter

flows are diminished as reservoirs are filled for the irrigation season, and summer flows are depleted at points below irrigation diversions.

No storage is authorized for water quality control although incidental benefits result from releases for other purposes.

Ground-Water Characteristics

Large supplies of ground water are available in certain areas of the Central Snake Subregion. The alluvial deposits consitute the major aquifer unit. Large yields are obtained for irrigation, municipal, and industrial use in the Boise, Payette, Weiser, Baker, Malheur, and Snake River Valleys. Volcanic rocks and lava furnish moderately large to large yields to wells between Boise and Mountain Home, southeast of Mountain Home, and in the Upper Weiser Valley, Cow Valley, and the Bruneau-Grand View area.

The general chemical character of most ground water is adequate for most purposes. Localized ground-water contamination occurs in the Boise River Valley and at some places where irrigation percolation has increased the mineral content. In most aquifer units, the dissolved solids are generally less than 500 mg/l. Some aquifers yield water with excessive sodium and sometimes with excessive fluoride. A more detailed discussion of ground water in the subregion is presented in Appendix V.

Pollution Sources

Municipal and industrial waste loadings and discharges, in population equivalents, are summarized by subbasin in table 74 for the Central Snake Subregion.

At present, municipalities and industries produce wastes equivalent to those from a population of about 1.59 million persons. Of this total, 68 percent is generated by the food-processing industry and 32 percent by municipalities.

Waste treatment and other means of waste reduction decrease the total organic load to the subregion's waters by about 52 percent, so that about 760,280 population equivalents actually reach waterways. Of this total, about 64,720 PE are released by municipalities and 695,560 PE are discharged by industries.

Other important sources of pollution are irrigation return flow, agricultural animals, and land use and management. Relatively minor pollution loadings result from rural-domestic sources, recreation, and natural sources.

Municipalities

Snake River and Other Tributaries Subbasin There are twelve communities in this subbasin which are served by municipal waste collection and treatment systems. Treatment practices are generally adequate with an average biochemical oxygen demand reduction of about 80 percent. Approximately 9,950 PE of organic wastes are released to watercourses.

The most significant waste loading in the subbasin occurs in the Ontario Service Area, which includes the communities of Ontario, Oregon; and Fruitland, New Plymouth, and Payette, Idaho. Approximately 5,300 PE of organic wastes are discharged to waterways. The Payette River receives about 4,100 PE and the Malheur River about 1,200 PE. The impact of these wastes is usually upon the Snake River, since organic wastes in the Malheur and Payette Rivers are not stabilized when they enter the Snake.

In the remainder of the subbasin, only three communities (Glenns Ferry, Idaho; and Adrian and Nyssa, Oregon) have less than adequate waste treatment (secondary or lagoons). However, the Oregon Water Quality Standards list Nyssa and Adrian as in need of secondary treatment or the equivalent by May 1970 and July 1972, respectively; and the Idaho Water Quality Standards require secondary treatment for Glenns Ferry.

Payette-Weiser Subbasin Municipal waste treatment practices in the Payette-Weiser Subbasin are below those in other subbasins of the Central Snake Subregion. An overall reduction of about 47 percent of the biochemical oxygen demand is accomplished by municipal waste treatment. As a result, approximately 6,970 PE are released to waterways. Of the six communities with waste collection and treatment facilities, four are in need of improved treatment facilities.

Inadequate septic tanks or no waste treatment facilities are employed at four communities in the subbasin, including McCall, Donnelly, Cascade, and Cambridge, Idaho. The Idaho Water Quality Standards require secondary treatment for these communities.

The only other significant municipal waste loadings are from Weiser, Idaho, which discharges about 3,500 PE to the Snake River; and Emmett, Idaho, which releases about 1,000 PE to the Payette River. The Idaho Water Quality Standards call for secondary treatment at Weiser by December 31, 1973.

Boise Subbasin Municipal waste treatment practices in the Boise Subbasin are generally adequate. Treatment facilities accommodate an 89 percent reduction in the biochemical oxygen demand

loading, allowing about 47,800 PE to be released to waterways. Of the 11 communities which have waste collection and treatment facilities, four provide secondary treatment. However, secondary treatment at Boise is in need of expansion to handle current waste loadings. Four communities have lagoons that provide satisfactory treatment. Three small communities (Star, Notus, and Wilder, Idaho) have no municipal treatment systems. The Idaho Water Quality Standards call for secondary treatment at these communities not later than 1970.

The Boise Service Area, which includes the communities of Boise, Garden City, Eagle, Star, Meridian, Middleton, Nampa, and Caldwell, is the principal municipal waste source in the subbasin. The cities of Boise, Caldwell, and Nampa--which provide secondary treatment--account for about 97 percent of the municipal waste loading (46,480 PE) discharged from the service area. Nampa recently constructed a combined secondary waste treatment plant which handles the wastes of the municipality, a sugar company refinery, and several food-processing plants. The installation handles about 330,000 PE and provides an oxygen demand reduction above 90 percent during the sugar-refining season from October to March. A waste loading of about 30,000 PE is discharged to Indian Creek a tributary of the Boise River, during this period. The cities of Boise and Caldwell discharge about 10,000 and 5,000 PE respectively, to the Boise River. Other municipal waste sources in the Boise Subbasin are relatively minor.

Industries

Snake River and Other Tributaries Subbasin Industrial waste sources are concentrated in the Ontario Service Area and at Nyssa, Oregon. An organic waste loading equivalent to that from a population of 583,100 persons is discharged from these areas. The two principal waste sources, a sugar refinery and a potato processing plant release about 290,000 PE each to the Snake River. The Oregon Water Quality Standards indicate that these industries have started construction of facilities to reduce waste loadings. The sugar refinery will provide a completely closed beet-fluming system, and the potato-processing plant will install secondary treatment. A canning company at Nyssa, Oregon, at Fruitland, Idaho, and Payette, Idaho, generate a total organic load of 141,000 PE. However, the canning industries practice efficient land disposal of waste waters, resulting in minor waste loading to streams. Several meat-packing plants within the service area represent minor waste sources. Adequate treatment is generally provided by the packing firms.

Other industrial waste sources in the subbasin are limited to small meat-packing plants at Homedale, Idaho, and at Adrian, Vale, and Baker, Oregon, and a cement plant at Lime, Oregon. The

Table 74 - Summary of Municipal and Industrial Waste Treatment, Subregion 5 1/

	Municipal					Industrial			
	Primary	Secondary	Lagoons	Other	Total	Sugar Processing	Potato Processing	Other Food Processing	Total
Snake River and other Tributaries Subbasin									
Number of facilities	2	1	8	1	12	1	1	11	13
Population served	6,000	10,000	19,750	1,300	37,050				
PE produced	9,000	12,000	26,050	1,500	48,550	290,000	290,000	95,200	675,200
PE discharged	6,000	300	2,650	1,000	9,950	290,000	290,000	4,160	584,160
% removal efficiency	33	98	90	33	80	0	0	96	13
Payette-Weiser Subbasin									
Number of facilities	1	0	2	3	6	0	0	1	1
Population served	4,000	0	4,200	2,400	10,600				
PE produced	5,000	0	5,700	2,400	13,100	0	0	25,000	25,000
PE discharged	3,500	0	1,070	2,400	6,970	0	0	0	0
% removal efficiency	30	--	81	0	47	--	--	100	100
Boise Subbasin									
Number of facilities	0	4	4	3	11	0	1	8	9
Population served	0	95,150	3,400	950	99,500				
PE produced	0	442,000	4,000	1,350	447,350	0	260,000	122,200	382,200
PE discharged	0	46,300	400	1,100	47,800	0	100,000	11,400	111,400
% removal efficiency	--	90	90	19	89	--	62	91	71
Total									
Number of facilities	3	5	14	7	29	1	2	20	23
Population served	10,000	105,150	27,350	4,650	147,150				
PE produced	14,000	454,000	35,750	5,250	509,000	290,000	550,000	242,400	1,082,400
PE discharged	9,500	46,600	4,120	4,500	64,720	290,000	390,000	15,560	695,560
% removal efficiency	32	90	89	14	87	0	29	94	36

1/ FWPCA inventory of Municipal and Industrial Wastes, Central Snake Subregion 1965.

meat-packing plants generally provide disposal by septic tanks and drain fields, although a meat packing company at Baker discharges wastes without treatment. A total organic waste loading of only about 1,060 PE is released by all of the packing firms. A cement company at Lime discharges small quantities of inorganic wastes without any type of treatment.

Payette-Weiser Subbasin The only significant waste sources in the Payette-Weiser Subbasin are at Emmett, Idaho. A canning company has land disposal facilities that are in need of expansion. Inorganic wastes from a sand and gravel company are released to the Payette River without any type of treatment. The Idaho Water Quality Standards require that silt removal facilities be installed.

Boise Subbasin Industrial operations in the Boise Subbasin are concentrated in the Boise Service Area. Food-processing plants along the lower rivers in the cities of Boise, Nampa, and Caldwell are the major sources of wastes. The largest waste producers are a food-freezing plant (potatoes, corn, and onions) at Caldwell and a sugar refinery at Nampa. Several minor food-processing plants and animal products manufacturing plants are also developed within the service area.

Even though a high degree of treatment is achieved, industries are responsible for the discharge of about 130,000 PE to subbasin waterways. A food processing plant at Caldwell is the main source of discharged wastes. The plant provides primary treatment with settling lagoons and land disposal of summer corn-freezing wastes, but lacks secondary waste treatment methods for winter potato-processing wastes. As a result, about 100,000 PE are released to the Boise River during winter months. The Idaho Water Quality Standards require secondary treatment of the potato-processing wastes by December 31, 1970. The City of Nampa has recently built a combined secondary waste treatment plant which handles the primary treated wastes of a large sugar company and several other food-processing plants. The installation has an oxygen demand removal efficiency of about 90 percent, resulting in an industrial waste discharge of about 20,000 PE to Indian Creek. The only other significant waste source in the Boise Service Area is a meat-packing plant at Boise. This plant has no conventional treatment facilities; however, the Idaho Water Quality Standards call for secondary treatment. At present, about 8,000 PE are discharged to the Boise River by the plant.

Outside of the Boise Service Area, the most important industrial pollution source in the subbasin is gravel-washing activities. Effects of gravel washing are most notable along the Boise River, where localized problems of turbidity and sedimentation are found.

The seasonal pattern of industrial operations has a significant effect on waste loadings. The sugar refining occurs in winter, with a start around the first of October that builds rapidly to a December peak and tapers off in March. Potato processing overlaps the sugar season, running from September through May at high levels. The canning and freezing season occurs between April and November, with peak waste production in August and September.

Rural-Domestic

Table 75 summarizes by subbasin and subregion that portion of the population served by individual waste disposal systems. Approximately 45 percent, or 121,300 persons, are classed as rural. The rural population generally depend upon disposal by septic tank and drain fields. Few problems are associated with the rural population, and the problems that do result are generally localized. However, untreated, unchlorinated sewage seepage from septic tanks is a source of bacterial contamination along the Payette River and Payette Lake.

Table 75 - Summary of Population Served by Individual Waste Disposal Facilities, Subregion 5 1/

Subbasin	Population Served Thousands	Percent Subregion Population	Percent Subbasin Population
Snake River and Other Tributaries	37.3	13.9	50.2
Payette-Weiser	21.5	8.0	67.0
Boise	62.5	23.3	38.4
TOTAL	121.3	45.2	

1/ Derived as a residual from FPCA Municipal and Industrial Waste Inventory, Central Snake Subregion, 1965.

Irrigation

There are about 1,465,000 irrigated acres in the Central Snake Subregion. The average water application rate in the area has been estimated at 3 feet per acre, indicating a total demand of 4.4 million acre-feet. An estimated 60 to 70 percent of the water applied to irrigation is taken up by evaporation and transpiration. Thus, about 3 million acre-feet of water currently being removed from the Central Snake River system does not return to the watercourses. The implications for flow and quality of the Snake River and tributaries are important.

The Snake River and several tributaries--Bruneau, Boise, Owyhee, Weiser, and Malheur Rivers--are extensively developed for irrigation use. The Payette, Burnt, and Powder Rivers have been far less developed although some large irrigation developments have taken place along these streams.

The effect of irrigation upon flows has been most evident in the Boise Subbasin. Depletion of streamflow by storage in Lucky Peak Reservoir during winter months and diversion for irrigation during summer months, coupled with various waste sources, have resulted in the curtailment of game fish production and a reduction in recreational opportunities and aesthetic values in and along about 50 miles of the lower Boise River.

Irrigation has little effect on water quality in the Weiser River. The very minor increase in total dissolved solids from the headwaters to the mouth and the river's ability to support high forms of aquatic life indicate that irrigation does not constitute an identifiable problem.

The Bruneau, Owyhee, and Malheur Rivers and several other tributaries that wind through the immense plateau south and west of the Snake are of very low quality although they are suitable for irrigation needs. Their natural quality is low, but intense irrigation use degrades them further. Each is largely depleted by irrigation, and their return flows are quite mineralized. The Malheur River near the mouth has an average dissolved solids content of over 1,000 mg/l.

Agricultural Animals

Agricultural animal drainage is a prime source of pollution in the Central Snake Subregion where there are three quarters of a million cattle. This represents an organic waste production equivalent to that from a population of five million persons. An estimated 95 percent of the loading is removed by soil action and natural decomposition so that about 250,000 PE reach waterways. The largest concentration of animals is found in the Boise River Valley, and the density of animal population on either bank of the Snake River from above the mouth of the Boise to the headwaters of Brownlee Reservoir is only slightly lower than that in the Boise River Valley.

Agricultural animals along streambanks tend to accelerate erosion and are a source of coliform bacteria and biochemical oxygen demand (BOD). In fact, waste drainages from the large numbers of animals along watercourses are partially responsible for the high bacterial densities that occur throughout the

subregion waterways. Streambank feedlots and dairies are situated at a number of points, providing unrestrained sources of serious bacterial contamination. Less concentrated and significant are pasture and grazing areas along watercourses and drainage ditches.

Other Land Use

Erosion, resulting in the transport of large volumes of earth to watercourses, is a perennial problem in much of the subregion. Sediment yields indicate that production ranges between 0.02 and 1.5 acre-feet per square mile per year. Only in one small area near Boise does the yield exceed 0.5 acre-foot per square mile per year. Most of the subregion has a yield of between 0.1 and 0.2. The predominant source of finer sediments is sheet and rill erosion on the upland watersheds. Additional amounts of fine sediment have been contributed by placer mining operations. Some of the coarser sand-size fractions are derived from sheet wash on steep mountain slopes, particularly where the cover density has been reduced by intensive grazing or fire. The cultivated lower valleys of the Boise, Malheur, and Owyhee Rivers carry heavy sediment loads to the Snake River during a thaw or after a rain.

Ridge and furrow irrigation is being practiced on about 90 percent of the irrigated land. While less wasteful than wild flooding, ridge and furrow irrigation sometimes results in surface runoff and accelerated erosion.

Clear-cutting in blocks for regeneration and release is the general silvicultural method of timber harvest although selective cutting methods are practiced in some special management areas. Timber harvesting, regardless of logging method, seldom provides a major waste source area. However, in many instances the roads, skid trails, and skid roads needed for harvesting timber cause major soil disturbances which serve as sediment source areas.

Construction activities which strip vegetative cover and disturb soils can be a major source of sediment. Highway construction, dam construction, and channel improvements add significantly to the total annual sediment load. The immediate impact of construction activities on streams tends to be localized and of short duration.

Present Water Quality

The quality of waters of the Central Snake River and its tributaries is generally suitable in most stream reaches for the uses made of those waters. The most serious and extensive water

quality degradations have been caused by excessive aquatic vegetation, sediment loads during the irrigation season and periods of maximum snowmelt, bacterial contamination below a number of populated areas, and dissolved oxygen deficiencies in several stream reaches.

Main Stem Snake River

As the Snake River enters the Central Snake Subregion, ground-water inflows in the Thousand Springs area create, in essence, a new river of excellent quality. A progressive deterioration in water quality occurs as the Snake flows through the subregion, particularly in the reach of the stream below the mouth of the Boise River. As the Snake River leaves the subregion, Brownlee Reservoir acts as a huge settling pond, releasing water that has undergone the natural processes of decomposition of organics, settling of suspended matter, cooling, and bacterial die-off. The water that passes from the dam has been improved within the reservoir.

Figure 33 presents a generalized dissolved oxygen profile for the Snake River. Dissolved oxygen concentrations of the Central Snake are usually found to be near the saturation level. However, a persistent oxygen depression occurs in the reservoir created by Brownlee Dam. Surface dissolved oxygen levels in the reservoir are consistently four or five milligrams per liter under the levels found immediately upstream. During late summer the deeper portions of the reservoir are frequently devoid of oxygen.

Biochemical oxygen demand (BOD) is a measure of the oxygen-utilizing potential of organic materials present in water. Figure 34 presents a generalized biochemical oxygen demand profile for the Snake River. In winter the BOD configuration is about what might be expected from a knowledge of waste discharges. Background levels around one mg/l rise sharply as a result of food-processing and other wastes of the Boise and Ontario Service Areas. From the Ontario Service Area to Brownlee Reservoir the BOD level recedes, since the rate of waste stabilization exceeds the rate at which oxygen-demanding materials enter the stream. In summer, biochemical oxygen-demanding concentrations are strikingly higher than would be expected from a knowledge of the greater flows and much lower waste loads that occur. Unlike pronounced winter biochemical oxygen-demanding concentrations which appear to depress dissolved oxygen concentrations at a number of points, high summer biochemical oxygen demand accompanies dissolved oxygen concentrations that are typically higher than 100 percent of saturation. The situation is presumed to be due to the prolific aquatic growths

found in the river. Release of oxygen in the respiratory processes of aquatic plant life compensates for the oxygen demand created by decomposition of the same kinds of biota.

The bacterial quality of the Central Snake River is highly variable. Coliform densities below service areas are usually high enough that the water is considered unsuitable for water-contact recreation (greater than 1,000 MPN/100 ml). Very high bacterial concentrations are found in the Snake River below the mouth of the Boise River. With the advance of waste treatment, the levels have dropped in recent years but are still considered to be above safe limits. Discharges of sanitary sewage are unquestionably responsible in some measure for high bacterial concentrations through most of the Central Snake. However, bacterial concentrations in the Central Snake derived in great part from the large animal populations and soil bacteria of the heavily irrigated agricultural areas also contribute to the problem.

Figure 35 presents a generalized water temperature profile for extreme winter and summer months under existing conditions of the Snake River. As the Snake enters the subregion in the Thousand Springs area, temperatures are moderate through the year, reflecting the fact that most of the flow is derived from springs. In winter, cooling results as the warmer, spring-fed waters pass through the subregion. In summer, significant temperature increases occur, since flow depletions due to storage and diversions and the surface return of irrigation waters warmed on fields act together to raise prevailing temperatures. During June and July the average monthly water temperature at King Hill is between 65° and 66°F. (18.3 to 18.9°C.). The average monthly water temperature is increased to over 70°F. (21.1°C.) at Weiser, and daily maximum temperatures of 75° to 76°F. (23.9 to 24.4°C.) are commonly recorded. Data from USGS "Weekly Runoff Reports" for 1967 show that the temperature below Brownlee Reservoir was as much as 10°F. (5.6°C.) lower than the inflowing water as measured at Weiser in July. Fall temperatures, however, are as much as 6°F. (3.3°C.) higher. These conditions are the result of summer stratification and low-level outlets at Brownlee Reservoir. Cold water in the lower levels of the reservoir is withdrawn during the summer months. By fall, waters available for release consist of accumulated warm summer inflows and resident reservoir waters which have been heated during the summer months. Because of the large reservoir volume, cool fall inflows have little influence on discharge temperatures.

Sediment and suspended organic material result in turbid conditions at many points. During periods of high runoff, sediment concentrations reach objectionable levels throughout the area. Suspended sediment samples in Jordan Creek showing instantaneous

concentrations as high as 20,700 mg/l were obtained during recent floods. In addition, suspended sediment concentrations of 17,200 mg/l and 3,310 mg/l have been reported in Bully Creek and the Middle Fork of the Payette River. Suspended organic matter is often found in heavy concentrations below food processing plants, although this problem is receding as waste treatment advances.

The average dissolved solids concentration as the Snake River enters the subregion is about 340 mg/l. The dissolved solids level of the Snake changes very little, even though the highly mineralized waters of the Malheur and Owyhee Rivers may exceed a concentration of 1,000 mg/l.

Figure 36 shows a generalized total phosphate profile for the Snake River. In the Thousand Springs area, phosphate concentrations decline due to the effect of dilution from ground-water inflow. However, concentrations are still considerably above 0.03 mg/l, often considered to be the threshold level for nuisance algal production. Tributary inflows of the Owyhee, Malheur, and Boise Rivers cause an increase in the level of phosphate concentrations. The deep pool environment of Brownlee Reservoir results in sequestration of phosphates, probably through the settling of dead aquatic growths that incarnate phosphorus. The result is that the Snake River below Brownlee carries much lighter loads of phosphates than it does within the reservoir.

High nitrate concentrations are evident at most points in the Central Snake River. There is a marked rise in the Thousand Springs area to concentrations above 1.0 mg/l, suggesting that ground-water inflows may be the major influence determining nitrate concentrations. Concentrations recede below Thousand Springs to about 0.5 mg/l at Brownlee Dam. Winter levels materially exceed those encountered in summer. No explanation is available, although it may be said that lower production of algae and other plants under winter climatic conditions restricts biological uptake of nitrates, while nitrates contained in wastes of food processing may add in some degree to concentrations.

The Central Snake River supports heavy concentrations of aquatic growths. While excessive growths of algae and water weeds are a type of pollutant throughout much of the subregion, they also constitute an influence on other pollution indicators. Most noticeable is the influence exerted on dissolved oxygen by plant respiration and on biochemical oxygen demand. Algae are probably the principal source of biochemical oxygen demand, far outranking domestic, municipal, and industrial wastes in this regard.

Tributaries

The quality of tributaries in the Central Snake Subregion varies. The mountain streams (Payette, Boise, and Weiser) tend to be clear and cool with high chemical quality. The Bruneau, Owyhee, Malheur, and other tributaries that flow through the immense plateau south and west of the Snake are usually warm and are high in sediment and dissolved solids. The Boise River is of excellent quality in its headwater areas, but various waste sources significantly degrade the quality in the lower reaches.

Dissolved oxygen levels tend to be high in tributaries. Even Indian Creek, a small stream that receives the wastes from Nampa, Idaho, maintains good dissolved oxygen levels. However, dissolved oxygen deficiencies are suspected in sections of the Boise River where, seasonally, waste discharges constitute the major portion of the flow. The dissolved oxygen pattern in the Boise River, as shown in figure 50, exhibits considerably diurnal fluctuation and was lowest during an August 1965 survey in the vicinity of Parma (5.3 mg/l). Photosynthetic and respirational activities of aquatic organisms are believed responsible for the diurnal DO fluctuation.

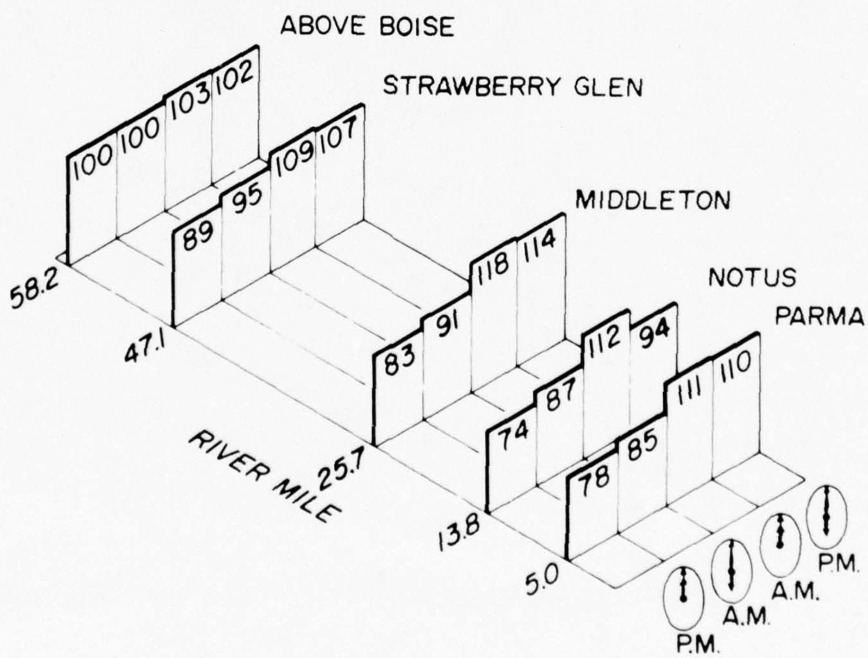


FIGURE 50. Dissolved Oxygen, Percent of Saturation, Boise River

Bacterial quality in tributaries is highly variable. In general, coliform densities below population centers are high enough that water is considered unsuitable for water-contact recreation (greater than 1,000 MPN/100 ml). However, a significant portion of high bacterial counts may be attributable to the large animal population. The Boise River has consistently been high in coliform densities, although the situation has improved in recent years. Even so, levels of 71,000 organisms/100 ml were recorded in the winter of 1965. Higher counts have been measured in Indian Creek, a tributary of the Boise River. Examples of the bacterial quality of the Boise River are given in figure 51 for four surveys. All surveys indicate a trend of increasing bacterial count from upstream to downstream.

Sediment and suspended organic materials result in turbid conditions at many points in the subregion. During periods of high runoff, sediment concentrations reach objectionable levels.

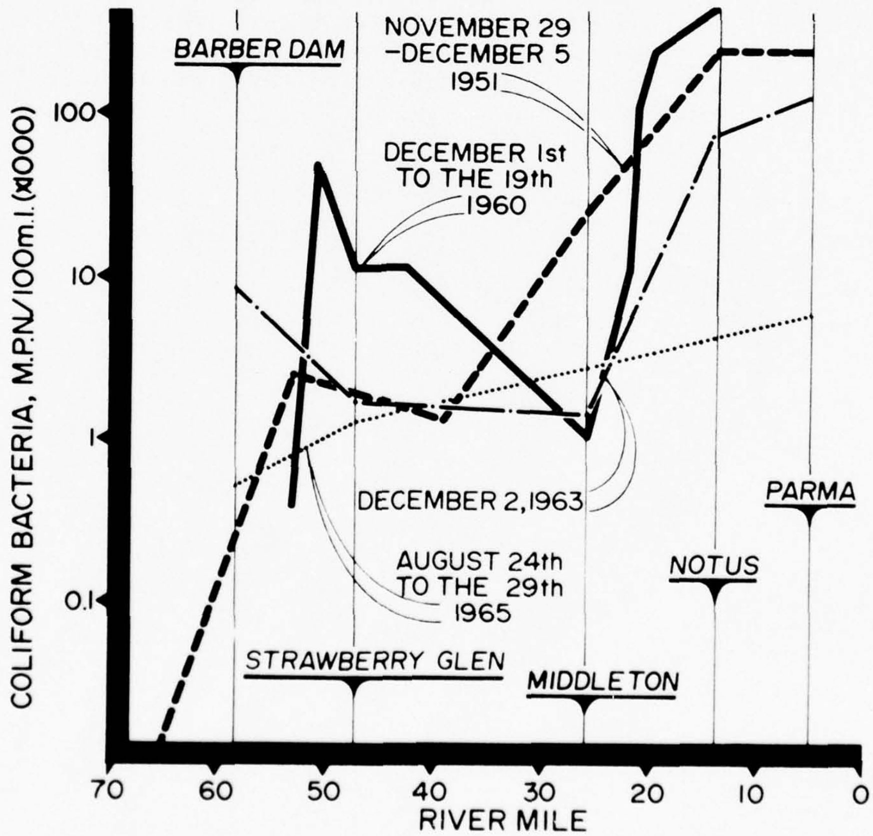


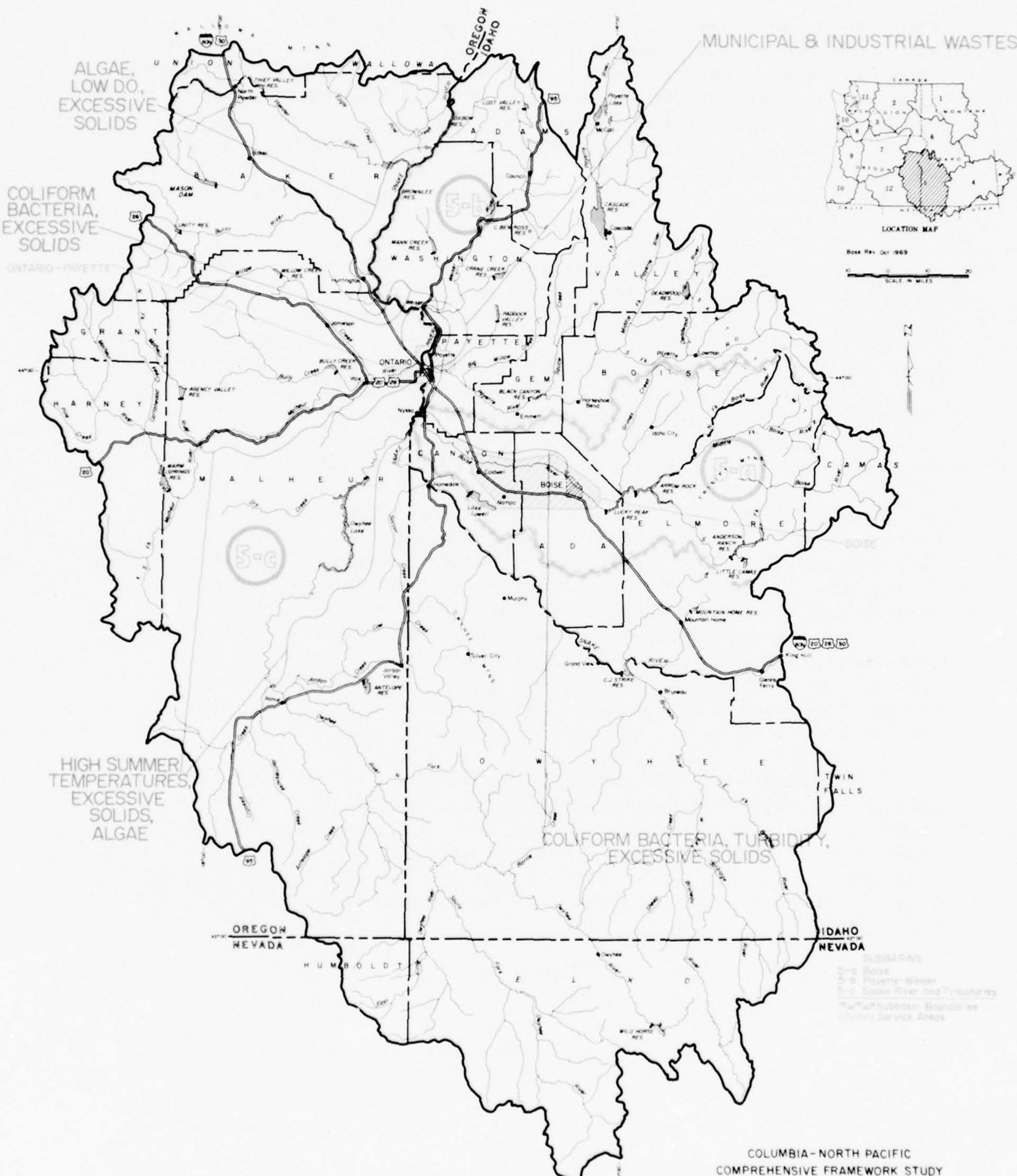
FIGURE 51. Coliform Bacteria Profile, Boise River

Suspended organic matter is often found in heavy concentrations below food-processing sites, although this problem is receding as waste treatment advances. The matter settles and results in sludge deposits which are extensive in the Boise River and noticeable elsewhere. Irrigation return flows are sometimes a source of localized turbidity during the summer. Silt, vegetable matter, and colloidal materials of soil or vegetable origin are often visible floating or in suspension in waters flowing through agricultural areas.

The natural chemical quality of the streams reflects the variation in climate. In the headwaters of the Boise, Payette, and Weiser Rivers, where precipitation averages about 40 inches, the waters are a dilute (less than 100 mg/l dissolved solids) calcium-magnesium bicarbonate type. The other streams draining this subregion (Bruneau, Owyhee, Malheur, and Powder Rivers) are typical of most semiarid areas of the Snake River. They contain fairly dilute (100 to 200 mg/l dissolved solids) bicarbonate type waters in their upper reaches. The amounts of calcium and sodium vary, with calcium usually predominating during the highflow periods. During most of the year, however, sodium is the predominate cation. Most of the streams show changes in mineral quality as a result of irrigation return flows. The dissolved solids concentration can increase tenfold or more, and the chemical composition is altered. The Owyhee, Boise, and Malheur Rivers show the greatest change. There is undoubtedly some downstream mineralization of the rivers as they flow through this semiarid area, but irrigation diversions and return flows have a much greater effect on the chemical composition of the water.

The waters of the Bruneau River and some of its tributaries contain fluoride concentrations in excess of the limits set for drinking waters by the Public Health Service. The average fluoride concentration of six samples collected from Little Valley Creek near Bruneau was 9.5 mg/l. Ten samples collected from the Bruneau River at Hot Springs during the 1959 water year averaged 2.7 mg/l fluoride.

Concentrations of basic nutrients, nitrogen and phosphorus, are high in several tributaries. The Owyhee, Malheur, and Boise Rivers have particularly high phosphate concentrations. High nutrient concentrations have stimulated heavy algal growths throughout the Owyhee and Malheur Rivers and in the lower reaches of the Boise River.



COLUMBIA-NORTH PACIFIC
COMPREHENSIVE FRAMEWORK STUDY

MAJOR WATER QUALITY PROBLEM AREAS

CENTRAL SNAKE SUBREGION 5

1969

FIGURE 52

Summary of Problems

A graphical summary of water quality problem areas in the Central Snake Subregion is presented in figure 52. The most serious problems have been associated with municipal and industrial wastes, agricultural animal wastes, and irrigation diversion and return flows.

The lower Boise River has repeatedly become polluted under circumstances that included low streamflow. Efficient waste treatment is generally practiced by the municipalities and industries in this reach, but diversions for irrigation and flow interruptions connected with the operation of Lucky Peak Dam have had undesirable consequences on downstream water quality. Also, agricultural drainages from cattle feedlots and irrigation return flows have contributed to increased stream temperatures, turbidity, bacterial contamination, and heavy algal growths in the lower Boise River.

The Snake River between the mouth of the Boise River and Brownlee Reservoir is characterized by settling and floating solids from the discharge of municipal and industrial wastes. These conditions have tended to form offensive and use-inhibiting nuisances. Bacterial contamination has also been evident in this reach. The states of Oregon and Idaho have done much to improve the situation by implementing stringent treatment programs. However, the problem still persists.

The waste materials in the central stretch of the Snake River are trapped in Brownlee Reservoir. The materials that settle include both silts and organics. As a result, Brownlee Reservoir has a constant oxygen deficiency of four to five milligrams per liter. Lush growths of algae mark the pool during much of the year, and anaerobic decomposition of organic material that has settled to the bottom of the pool produces noxious odors when reservoir turnover occurs.

The Owyhee and Malheur Rivers have naturally low water quality, and intensive irrigation use degrades them further. These streams are seasonally warm, high in sediment and dissolved solids, and burdened with heavy aquatic growths.

FUTURE WATER QUALITY MANAGEMENT NEEDS

Based on the projected economic development of the Central Snake Subregion, the population is expected to increase from 268,500 in 1965 to 553,500 in 2020. This is an increase of 106 percent for the subregion, compared with 121 percent for the region.

The projected subregion populations for the years 1980, 2000, 2020 are shown in figure 53. The projected subbasin and service area populations for municipal and rural categories are presented in table 76. The municipal component of the projections is defined as that portion of the population which is served by public sewage collection systems. By 2020, nearly three-fourths of the subregion's population is expected to be located in the Boise and Ontario Service Areas. The balance of the population will be fairly evenly distributed throughout the subregion, with larger concentrations at Baker, Oregon, and at Emmett and Mountain Home, Idaho.

Future industrial development will be based on the subregion's agricultural resources. Food processing will continue to dominate in the production of organic wastes, although it is expected that a pulp and paper mill producing significant wastes will locate in the subregion by 1980. Production of lumber and wood products is expected to decrease slightly over the projection period.

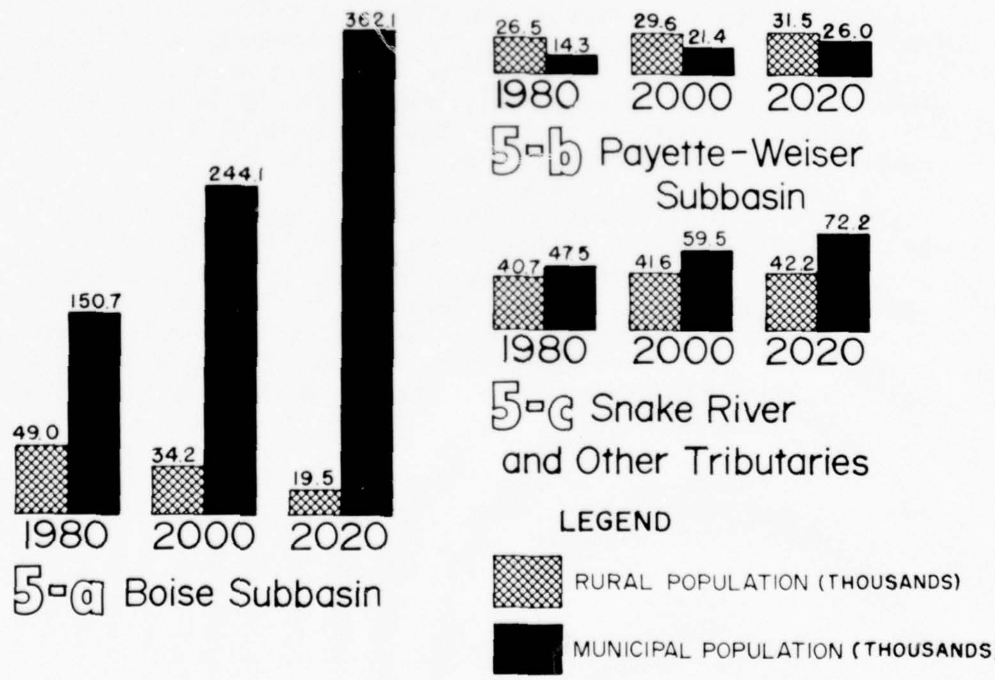


FIGURE 53. Projected Population, Subregion 5

Table 76 - Projected Population, Subregion 5 1/

	1980	2000 (thousands)	2020
Payette-Weiser Subbasin	40.8	51.0	57.5
Municipal	14.3	21.4	26.0
Rural	26.5	29.6	31.5
Boise Subbasin	199.7	278.3	381.6
Boise Service Area	182.2	259.8	362.1
Municipal	150.7	244.1	362.1
Rural	31.5	15.7	-
Other	17.5	18.5	19.5
Municipal	-	-	-
Rural	17.5	18.5	19.5
Subtotal	199.7	278.3	381.6
Municipal	150.7	244.1	362.1
Rural	49.0	34.2	19.5
Snake River and Other Tributaries	88.2	101.1	114.4
Ontario-Payette Service Area	21.7	28.2	37.4
Municipal	19.9	27.3	37.4
Rural	1.8	0.9	-
Other	66.5	72.9	77.0
Municipal	27.6	32.2	34.8
Rural	38.9	40.7	42.2
Subtotal	88.2	101.1	114.4
Municipal	47.5	59.5	72.2
Rural	40.7	41.6	42.2
Total Subregion	328.7	430.4	553.5
Municipal	212.5	325.0	460.3
Rural	116.2	105.4	93.2

1/ Derived from Economic Base and Projections, Appendix VI, Columbia-North Pacific Framework Study, January, 1971 and from North Pacific Division Corps of Engineers data. Differences between totals in this table and source are due to differences in subregion boundaries. The source is based on economic boundaries and this table is based on hydrologic boundaries. The municipal population is defined as that population discharging wastes to a municipal sewerage system. The rural population is defined as the residual.

Future Waste Production

Municipal

The projected municipal raw waste production for the Central Snake Subregion is presented in table 77. The portion of the subregion's population served by municipal waste collection and treatment systems is expected to increase from 55 percent in 1965 to 83 percent by the year 2020. It has been assumed that the entire populations of the two major service areas will be served by municipal systems at that time.

Table 77 - Projected Municipal Raw Organic Waste Production, Subregion 5 1/

	1970	1980	2000	2020
		(thousand PE's)		
Payette-Weiser Subbasin	14.8	17.9	26.8	32.5
Boise Subbasin	145.8	188.4	305.1	452.6
Boise Service Area	143.7	188.4	305.1	452.6
Other	2.1	-	-	-
Snake River and Other Tributaries	50.7	59.4	74.3	90.3
Ontario-Payette Service Area	18.3	24.9	34.1	46.8
Other	32.4	34.5	40.2	43.5
Total Subregion	211.3	265.7	406.2	575.4

1/ A factor of 1.25 was applied to the municipal population components to account for the effects of small commercial establishments and other urban activities which add to municipal waste loads.

The two major service areas are expected to produce 87 percent of the subregion's municipal waste loading in 2020, as compared with 76 percent in 1965. The Boise Service Area will account for nearly 79 percent of the total subregion municipal waste production by 2020.

Industrial

Projected raw organic waste loadings for the major industrial categories are presented in table 78 for the years 1980, 2000, and 2020. By the end of the projection period, it is expected that industries will contribute approximately 84 percent of the subregion's total organic waste loading. The food-processing industry will continue to be the largest organic waste source, contributing approximately 70 percent of the industrial waste

production. The pulp and paper industry will become a major source of organic wastes by 2020, contributing 30 percent of the industrial wastes produced.

It is assumed that future growth will occur at existing operations for most industries. Based on that assumption, most of the food-processing waste increases will occur in the Boise and Ontario-Payette Service Areas. The projections assume that a pulp and paper plant will locate in the subregion by 1980, and will grow to five times its initial size by 2020. It is expected that such an operation would locate near Weiser, Idaho, because the streamflows at that point would best assimilate the wastes produced. However, the effects of the waste discharges on Brownlee Reservoir and the river downstream should be carefully evaluated before allowing waste discharges at this location.

Table 78 - Projected Industrial Raw Organic Waste Production, Subregion 5 1/ (5) (17)

	1970	1980	2000	2020
		(1,000's P.E.)		
Food Products	947.7	1,218.0	1,825.0	2,451.0
Pulp and Paper	0.0	200.0	530.0	1,070.0
Total	947.7	1,418.0	2,355.0	3,521.0

1/ Base data from FWPCA inventory of municipal and industrial wastes, Central Snake Subregion, 1965.

Rural-Domestic

The projected rural-domestic waste production is summarized in table 79 for the years 1980, 2000, and 2020. The rural-domestic waste production was assumed to be equal to the rural population component shown in table 76. For most areas in the subregion, the rural waste production is expected to remain relatively constant or to increase slightly. However, the Boise Subbasin shows a significant decrease in rural waste loadings.

Table 79 - Projected Rural Domestic Raw Organic Waste Production, Subregion 5

	1970 1/	1980	2000	2020
		(1,000's P.E.)		
Payette-Weiser Subbasin	23.2	26.5	29.6	31.5
Boise Subbasin	57.9	49.0	34.2	19.5
Snake River and Other Tributaries	38.4	40.7	41.6	42.2
Total Subregion	119.5	116.2	105.4	93.2

1/ Interpolated from 1965 data and 1980 projections.

Septic tanks and some type of subsurface drainage systems are the most likely method to be used to dispose of wastes from individual residences in the future. No widespread problems are anticipated from this source in the future, although corrective measures may be necessary in areas bordering lakes and streams, or where the water table is high.

Irrigation

Approximately 1,465,000 acres of land are presently being irrigated in the subregion. By 2020, an additional 995,000 acres of irrigated land and supplemental water supplies for 383,000 acres now under irrigation will be required to meet projected food and fiber needs. A farm delivery of 4,750,000 acre-feet of water annually is required to serve lands now under irrigation. About six million acre-feet are diverted annually from surface waters to provide the 4.75 million acre-feet farm delivery requirement. By 2020, an estimated diversion of about 10.5 million acre-feet annually will be required to meet a farm delivery requirement of 8.46 million acre-feet. This amount of water will meet the present irrigation needs, supplemental water needs, and future new irrigation needs.

Better management and application of the subregion's irrigation water supplies is needed. Curtailment of streamflows during fall and winter months to fill storage reservoirs when food-processing operations are discharging peak waste loads has contributed to serious pollution problems in the past. As additional storage space is developed to control basin runoff, and as more food-processing activities result from increased agricultural production, the problems will grow worse under present operational methods. More efficient use of irrigation water, both on-farm and within conveyance systems, will be necessary to maintain water quality standards criteria in the future. Conversion from rill and furrow to sprinkle application methods would require less water to be diverted from streams and would reduce the amount of irrigation return flows entering surface waters.

Other Land Uses

Projections of land use in the subregion, by major types of use, are shown in table 80. The projections show a decrease in land area for forest and woodland of approximately 1.5 percent by the year 2020. In contrast, the wood consumption demand by the forest products industry is expected to increase 21.6 percent during the same period. The potential for erosion and stream damage will be greater as more intensive harvesting methods are

employed. Increased sediment loads for adjacent streams may result.

Erosion is a perennial problem in much of the Central Snake Subregion. There is an urgent need for improved land management practices to reduce sediment yields below levels experienced in the past.

Use of fertilizers on new agricultural lands bordering streams and lakes could add to nutrient levels occurring in the subregion's surface waters and could aggravate eutrophication problems that are already quite severe in some areas. Pesticides and herbicides applied to these lands could also drain into the water bodies and build up to toxic concentrations in higher levels of the aquatic life forms in these waters. However, by restricting the use of pesticides and instituting better management practices in the use of fertilizers, pesticides, and herbicides on all lands, water quality degradation from these sources could be minimized.

Table 80 - Projected Land Use, Subregion 5 (5) (8)

	1966	1980	2000	2020
		(1,000 acres)		
Land Use				
Cropland	1,629	2,082	2,184	2,453
Irrigated	(1,421)	(1,900)	(2,062)	(2,389)
Nonirrigated	(208)	(182)	(122)	(64)
Forest	4,191	4,174	4,152	4,129
Range 1/	16,839	16,332	16,200	15,897
Other 2/	739	764	795	830
Miscellaneous	(73)	(80)	(90)	(102)
Total	23,398	23,352	23,331	23,316

1/ Does not include forest range.
2/ Includes barren land, roads, railroads, small water areas, urban and industrial areas, farmsteads, airports, etc.

Agricultural Animals

The raw organic waste production by the livestock population in the subregion is expected to be equivalent to that from a population of 7,900,000 in 1980, 10,500,000 in 2000, and 13,800,000 in 2020. This would account for approximately 77 percent of the total raw organic waste loading for the subregion by the end of the projection period. It is estimated that about five percent of the wastes generated by a normally distributed animal population eventually reaches the waterways. This is not

the case, however, where large numbers of animals are concentrated in small spaces as they are in feedlots and dairies. The potential for pollution from these sources is high, particularly at those operations which are located along streambanks. Economical methods of control and disposal of feedlot wastes need to be developed and applied to all operations bordering surface waters. It may be necessary to treat wastes at other locations where the potential for ground-water pollution is high.

The concentration of animals now situated in Boise Valley and along the Snake River from the mouth of the Boise to the headwaters of Brownlee Reservoir is expected to increase in the future, with accompanying waste-control problems.

Recreation

As the demand for water-based recreation continues to outpace population growth, the wastes resulting from these activities are expected to continue increasing at a rapid rate. Construction and expansion of adequate waste disposal facilities at recreation areas must keep pace with the increased recreational use if water pollution from this source is to be prevented. The following summary of projected raw waste production by recreational activity gives an indication of the amount of future construction that will be required.

Year	Population Equivalents 1/
1970	95,000
1980	128,500
2000	237,000
2020	436,500

1/ Bureau of Outdoor Recreation and U.S.D.A. Forest Service Projections for total man recreation days (TMRD).

Many of the subregion's lakes and reservoirs that now receive heavy recreational use will be used to their full potential by the end of the projection period. Lucky Peak, Anderson Ranch, and Cascade Reservoirs are expected to receive particularly heavy use.

Other Factors Influencing Quality

The growths of unsightly algae that occur annually in some streams and reservoirs are a serious water quality problem that detract from most water uses, particularly fishing and recreational pursuits. These growths have been quite troublesome in the Snake River and Brownlee Reservoir in the past. Algal growths flourish in impounded waters where water temperatures are maximum and water

circulation is minimum. Construction of storage reservoir to meet future water needs is expected to add to this problem, not only in the impoundment itself, but downstream as well.

Although hydropower production is not a major water user and has not been directly associated with subregion water quality degradation in the past, the potential for adverse water quality effects is great at installations that are not operated to minimize these effects.

Quality Goals

Quality goals are based on State water quality standards criteria established for the subregion waters. Water quality standards for Idaho, Oregon, and Nevada apply to portions of the subregion; however, the standards adopted by Nevada are of minor concern to maintenance of water quality in the Central Snake drainage since the subregion streams in this State are small headwater tributaries of the Owyhee and Bruneau Rivers in areas having very little pollution potential. The standards of all three states contain two provisions that are critical to the maintenance of high quality water: one, the anti-degradation provision which states that waters whose existing quality is better than the established standards will be maintained at that high quality and; two, the provision that the highest and best practicable treatment under existing technology will be applied to all waste discharges.

Waters in Idaho are protected for domestic and industrial water supply, irrigation, livestock watering, propagation of salmonid fishes, and recreation uses. Generally, the criteria established to protect these uses will not allow waste discharges that will cause the dissolved oxygen to be less than 75 percent saturation at seasonal low, or less than 100 percent in spawning areas during spawning, hatching, and fry stages of salmonid fishes; the temperature to exceed 68°F. (20°C.); objectionable turbidity; or the average coliform concentrations to exceed 240 per 100 ml along the shores of lakes, or 50 per 100 ml in the main body of a lake or stream.

Waters in Oregon are protected for domestic and industrial water supply, irrigation, livestock watering, salmonid fish propagation, and recreation uses. The criteria established to protect these uses will not allow waste discharges or activities that will cause dissolved oxygen to be less than 75 percent of saturation at seasonal low or less than 95 percent of saturation in spawning areas during spawning, hatching, and fry stages of salmonid fishes; the average coliform concentrations to exceed 1,000

per 100 ml; turbidity to exceed 5 Jackson Turbidity Units over background values; any measurable increase when temperatures are 70°F. (21°C.) or above, or more than 2°F. (1.1°C.) increase when temperaturees are 68°F. (20°C.) or below; or the hydrogen-ion concentration to fall outside the range of 7.0 to 9.0.

Waters in the Nevada portion of the subregion are protected for fish and wildlife, aesthetics, wastewater assimilation, irrigation, and stock-watering uses. The criteria established to protect these uses vary appreciably by stream and reach, but in general they will not allow activities or waste discharges that cause dissolved oxygen concentrations to be less than 7 mg/l; biochemical oxygen demand to exceed 10 mg/l; temperatures to exceed 27°C. (81°F.) in summer or 14°C. (57°F.) in winter; hydrogen-ion concentration to fall outside the range of 6.5 to 8.5; chloride concentrations to exceed 5 mg/l; phosphate concentrations to exceed 0.1 mg/l; nitrate concentrations to exceed 1.0 mg/l; or total dissolved solids concentrations to exceed 250 mg/l.

The above uses and criteria apply generally to the waters of the subregion, but water quality standards documents should be consulted for information on specific waters. A complete set of each state's water quality standards is available upon request from the following state agencies: Idaho Department of Health; Oregon State Department of Environmental Quality; and Nevada Department of Health and Welfare.

MEANS TO SATISFY DEMANDS

Controlling pollution in the Central Snake Subregion to provide water quality adequate to serve the river system's functions will require a coordinated program of waste reduction, flow regulation, application of waste-controlling techniques, and development of a system of cooperative management of the watershed for pollution control.

Waste Treatment

Future Waste Discharges

Based on the treatment levels shown in the Regional Summary and the raw waste projections presented earlier, the projected municipal waste loadings to be discharged to waters of each subbasin are shown in table 81. The industrial waste loadings for major industrial categories are presented in table 82. The total municipal and industrial organic waste loading is expected to be 252,600 PE in 1980; 276,100 PE in 2000; and 409,600 PE in 2020.

Table 81 - Future Municipal Organic Waste Discharges, Subregion 5

	1980	2000	2020
		(1,000's P.E.)	
Payette-Weiser Subbasin	2.7	2.7	3.2
Boise Subbasin	28.3	30.5	45.3
Boise Service Area	28.3	30.5	45.3
Other	-	-	-
Snake River and Other Tributaries	8.9	7.4	9.0
Ontario-Payette Service Area	3.7	3.4	4.7
Other	5.2	4.0	4.3
TOTAL SUBREGION	39.9	40.6	57.5

Table 82 - Future Industrial Organic Waste Discharges, Subregion 5

	1980	2000	2020
		(1,000's P.E.)	
Food Products	182.7	182.5	245.1
Pulp and Paper	30.0	53.0	107.0
TOTAL	212.7	235.5	352.1

By 2020, about 79 percent of the municipal waste load is expected to originate in the Boise Service Area and 8 percent in the Ontario-Payette Service Area. The remaining municipal waste load will be fairly evenly scattered among the numerous small communities in the subregion.

The largest organic loads, representing 60 percent of the total municipal and industrial loads produced by 2020, will stem from food-processing endeavors. The major part of the food-processing load is generated at potato plants located in the Boise and Ontario-Payette Service Areas. Substantial growth in the industry is expected to occur in these two areas.

The projections assume that a pulp and paper plant will locate in the subregion by 1980 and by 2020 will be discharging an organic waste load equivalent to that from a population of 107,000. It is assumed this plant will locate in the vicinity of Weiser, Idaho.

Treatment Costs

Curves showing estimated costs of constructing (total capital) and operating (annual operation and maintenance) municipal

sewage treatment plants for various treatment levels are presented in the "Means to Satisfy Demands" section of the Regional Summary.

Other Pollution Control Practices

Rural wastes will be of major significance in a number of areas. Disposal of rural wastes to septic tanks and drain fields will continue to represent a hazard to ground water in the Boise Valley and a number of other localized areas throughout the subregion. Where warranted by the population densities, the best solution in the problem areas is to construct sewage collection and treatment facilities. Where such construction is not feasible, alternative disposal methods must be considered on an individual basis.

The large animal population in the subregion, particularly those animals in large feedlots along surface waters, represents one of the largest sources of organic wastes in the subregion. Fences and simple retaining structures between the animal habitat and watercourses should be provided in order to prevent bank erosion and to limit direct surface drainage so that wastes may decompose through soil processes. At some places it may be preferable to collect the waste from cattle-holding facilities for treatment or for distribution to the land as a fertilizer.

Recreation areas will be increasing in numbers, size, and intensity throughout the subregion. Sewage disposal systems adequate to cope with weekend loads from use by thousands will be needed in many recreation areas. Facilities for collection and pickup of litter and garbage must also be made available, since these things may add to the waterborne debris load. Restrictions on motorboats on heavily used lakes may be necessary to keep oil and gas pollution at a minimum. Sanitary waste treatment or holding facilities should be required on all watercraft. Facilities to receive the contents of boat holding tanks should also be available at all launching sites.

The lower reaches of the Malheur, Owyhee, and Boise Rivers are mostly irrigation return flows and M&I waste loads in summer months. Nutrient, sediment, and dissolved solids content of these wastes is the prime factor in the poor quality of water in these reaches and in the Snake River below the mouth of the Boise River in late summer months. Nutrient content of these wastes contributes to severe algal growths and accompanying aesthetically displeasing appearance of the waters in these reaches. Improved irrigation practices and control of irrigation return flows and better M&I treatment are essential to restore the quality of these waters. Improved land management practices are also badly needed.

Detailed studies of the algae problem are needed to better define the controls necessary to alleviate present conditions. The sources of nutrients and their point of entry into surface

waters must be known to determine the potential for algae reduction through nutrient control.

Some method of maintaining the outflow at Lucky Peak Dam must be devised to avoid water quality problems caused by shutdown of the single outlet for service. Construction of a hydropower plant to pass flows during this maintenance period is one solution that has been considered.

Minimum Flow Requirements

Since waste treatment cannot be applied to noncollectable wastes and does not economically remove all contaminants from collectable wastes, a certain amount of streamflow is necessary for dilution and assimilation of residual wastes reaching the streams. Generalized curves showing minimum flow requirements for raw waste loadings subjected to various treatment levels are presented in figures 54 and 55. These figures give approximate requirements based on dissolved oxygen standards criteria only for small to middle-sized communities located on tributary streams. Figures 54 and the first curve in figure 55 are based on minimum dissolved oxygen concentrations allowable at seasonal low. In those locations where existing quality is above the minimum established in the water quality standards documents, the anti-degradation provision applies. The second curve in figure 55 presents estimated minimum flow needs for various waste treatment levels at locations where this provision applies. The curves may also be used to indicate ranges of flows needed to assimilate industrial or agricultural wastes, although they were developed primarily for application to municipal waste discharges. The areas to which the individual curves apply are delineated in figure 56.

All curves are necessarily based on very broad assumptions and are intended to give an indication of the magnitude of flows versus treatment needed to maintain dissolved oxygen standards only. Other standards criteria will control in many cases and could very likely require that flows two or three times greater than those shown in the figures be provided. For example, in some areas it has been necessary to maintain a 20/1 streamflow/effluent dilution ratio to prevent slimes and other aesthetically displeasing conditions occurring below secondary treated sewage discharges. Based on per capita waste flows expected in 2020, a streamflow of 54 cfs would be needed to provide this dilution to secondary effluent from a community of 10,000 persons. This is about twice the flow that would be required to meet a dissolved oxygen standard allowing a deficit of 1.0 mg/l.

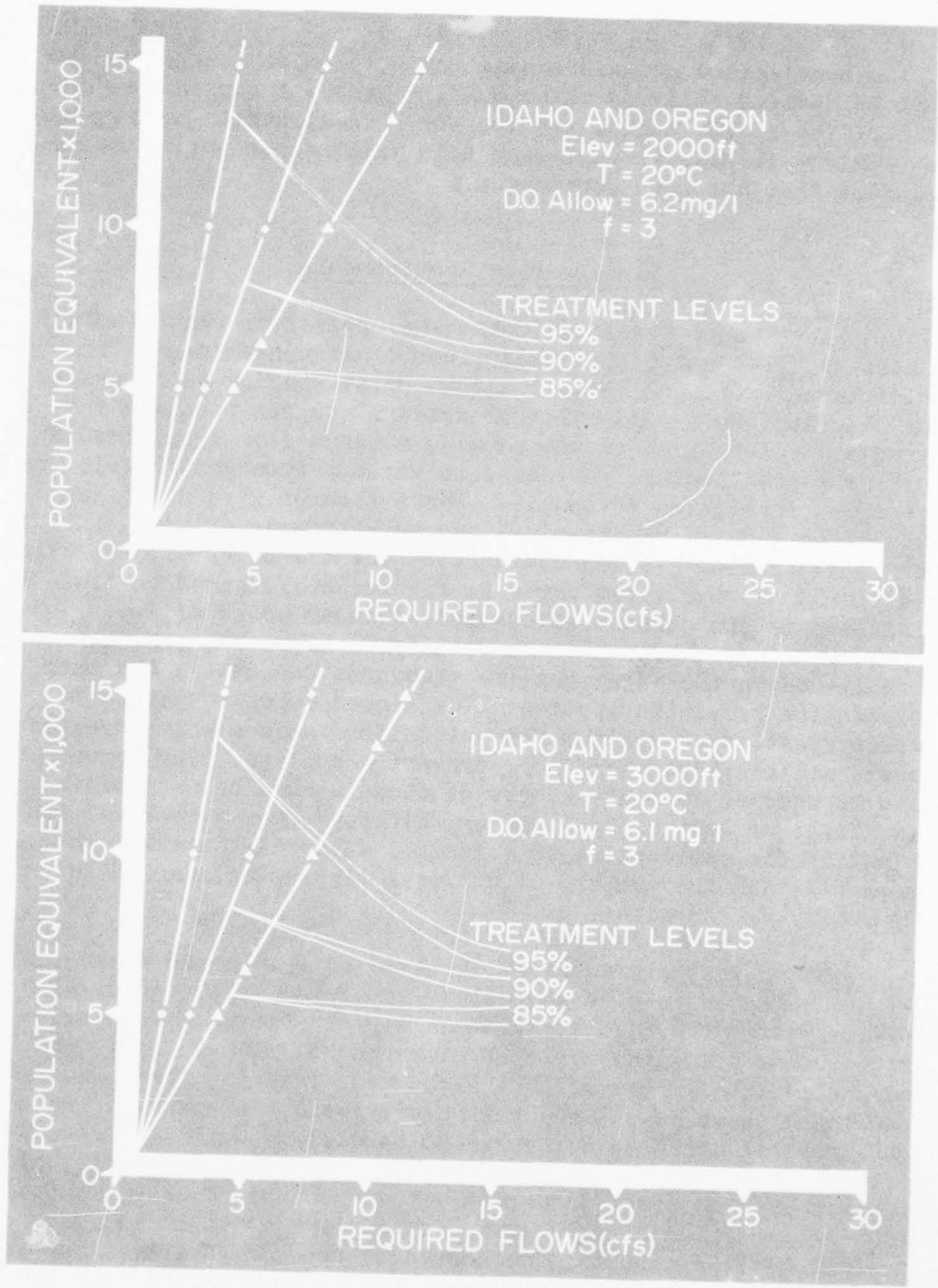


FIGURE 54. Minimum Flow Needs to Maintain Idaho and Oregon Dissolved Oxygen Standards Criteria

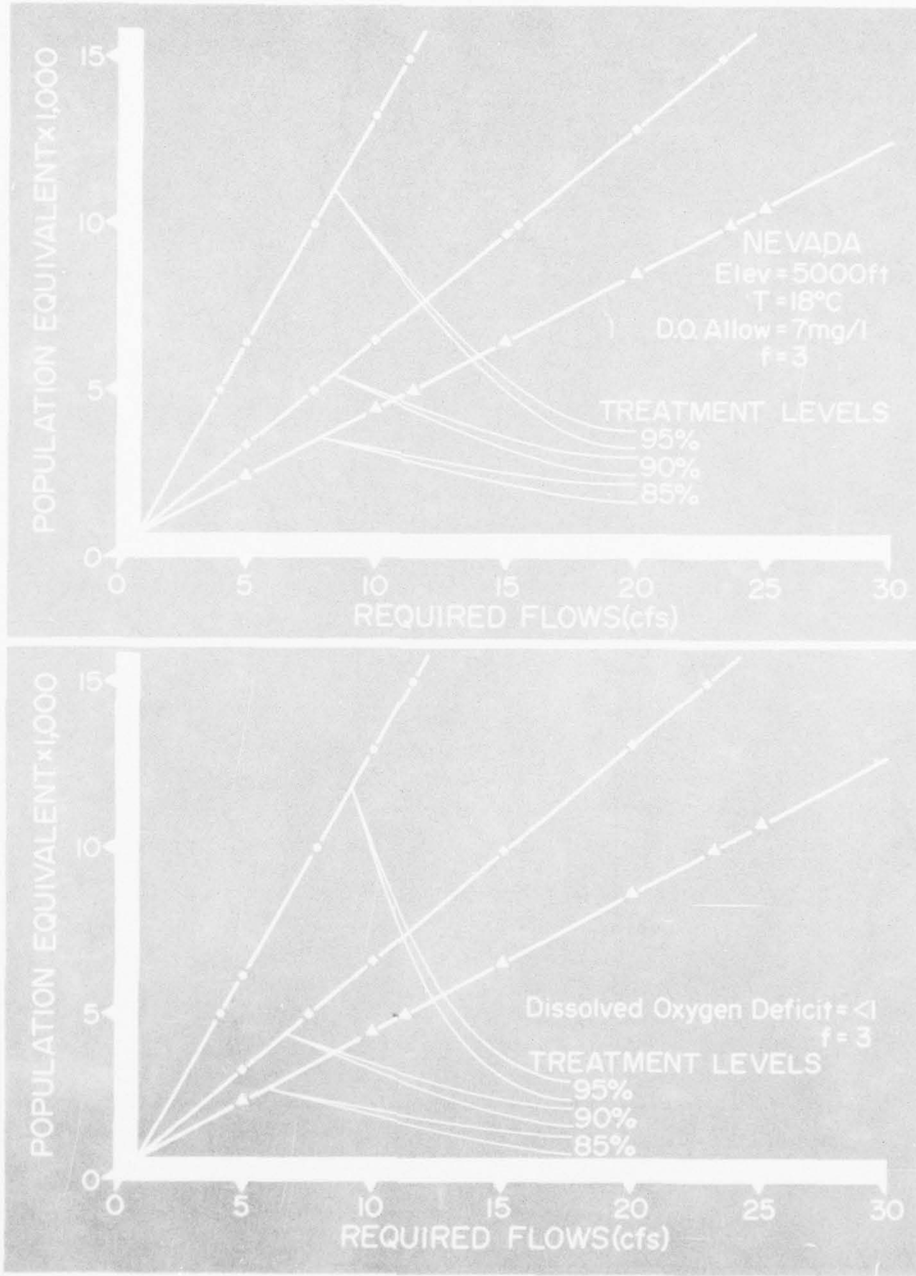
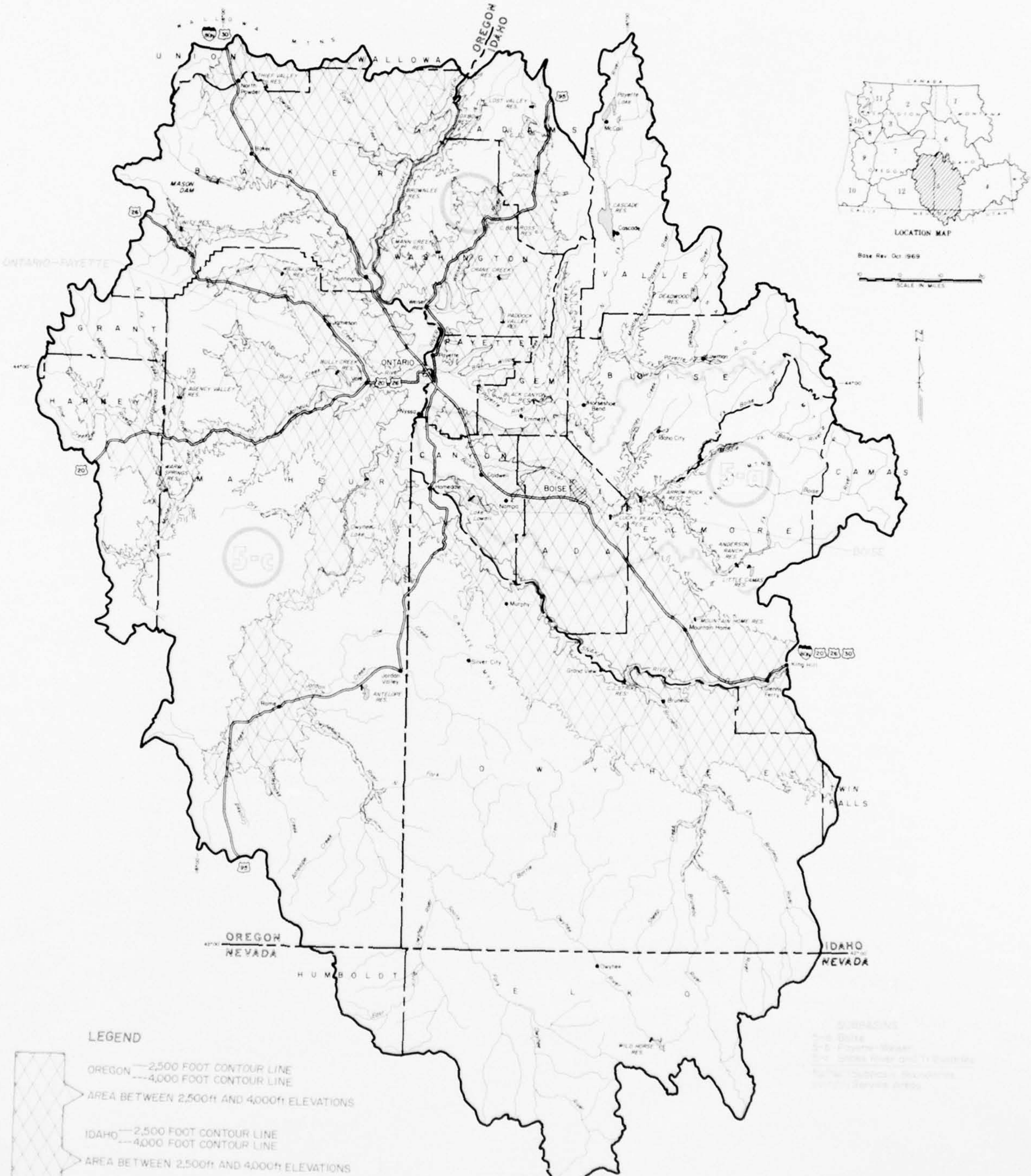


FIGURE 55. Minimum Flow Needs to Maintain Nevada Dissolved Oxygen Standards Criteria



COLUMBIA-NORTH PACIFIC
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AREAS TO WHICH FIGURES 54&55 APPLY

CENTRAL SNAKE SUBREGION 5

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FIGURE 56

In addition to the general curves in figures 54 and 55, specific flow requirements to meet dissolved oxygen standards criteria have been computed for stream reaches below large municipal and/or industrial waste discharges. The computed f ow requirements are discussed by reach in the following paragraphs.

Main Stem Snake River

Flow needs by month to maintain dissolved oxygen standards criteria under present and projected waste loadings have been computed for the Snake River below the mouth of the Boise River. Curves of these needs in cfs, plotted by projection year for 85, 90, and 95 percent treatment efficiencies, are presented in figure 57. The curves represent flows needed during the month having the

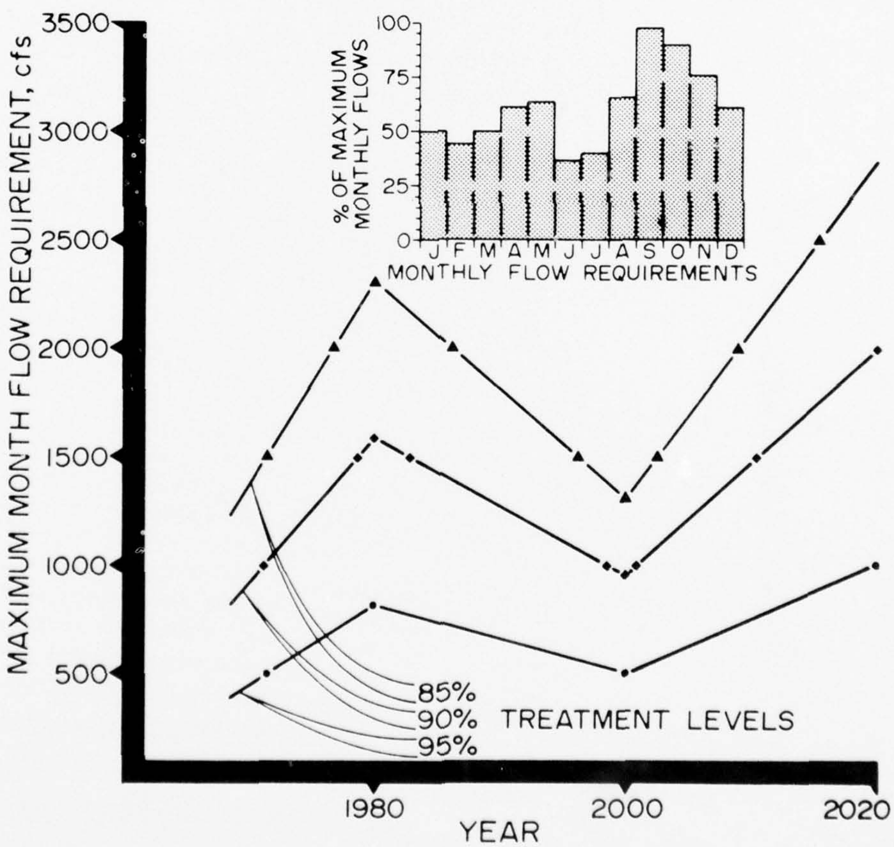

FIGURE 57. Minimum Flow Needs for Water Quality Control, Snake River at Payette

Note: Average annual flow is 62 percent of the maximum month flow.

highest requirement. The maximum month varies by type of waste loading and location, although it usually is September or October when peak food-processing wastes are discharged. The annual distribution of required flows by month, expressed as percentages of the maximum month requirement, is also shown for the year 2020. The annual distribution varies somewhat for interim years of the projection period, but the 2020 distribution can be used to approximate flow needs for these years and stay well within the overall accuracy of the study. Also, the average flow requirement for any year can be derived by applying the average annual percentage factor to the maximum month requirement for the year in question.

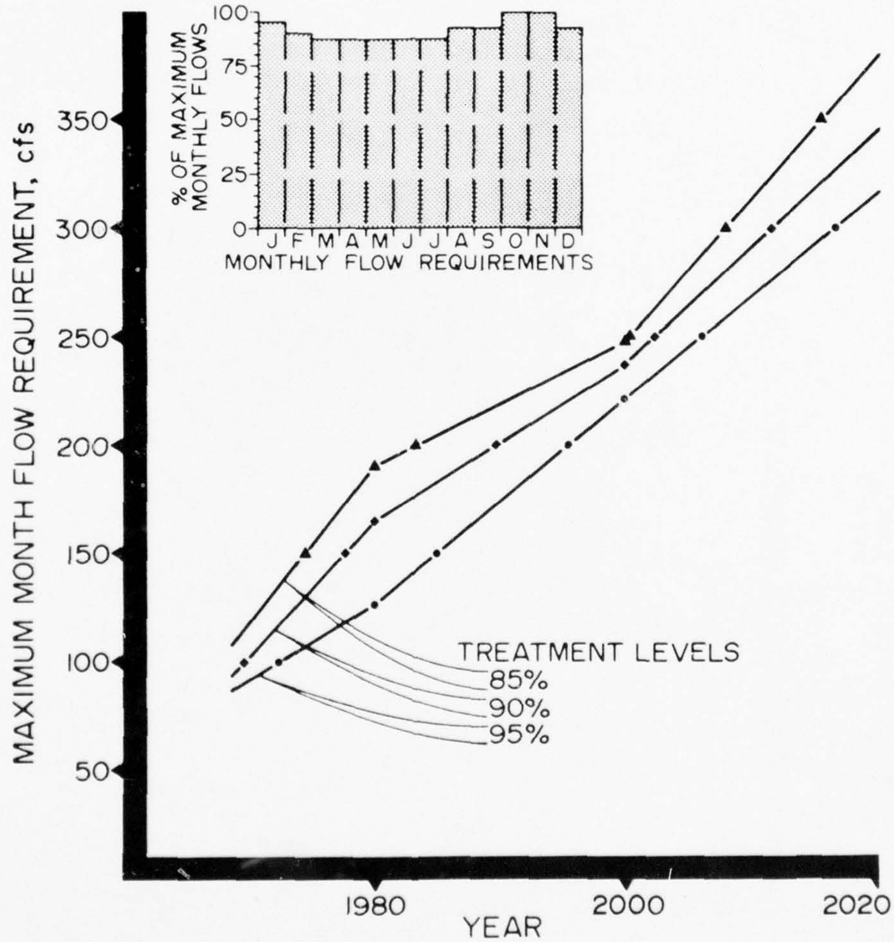

FIGURE 58. Minimum Flow Needs for Water Quality Control, Boise River at Boise

Note: Average annual flow is 91 percent of the maximum month flow.

Flow needs are based on residual waste discharges reaching the Snake River from the Boise River, and primarily on sugar beet and potato processing loads discharged from the Ontario-Payette Service Area. The dip in the curve for 2000 is the result of the assumption that in-plant controls would curtail the discharge of sugar beet processing wastes by that time.

Boise River

Figures 58 and 59 contain curves of flow needs during the projection period for the Boise River at Boise and at Caldwell,

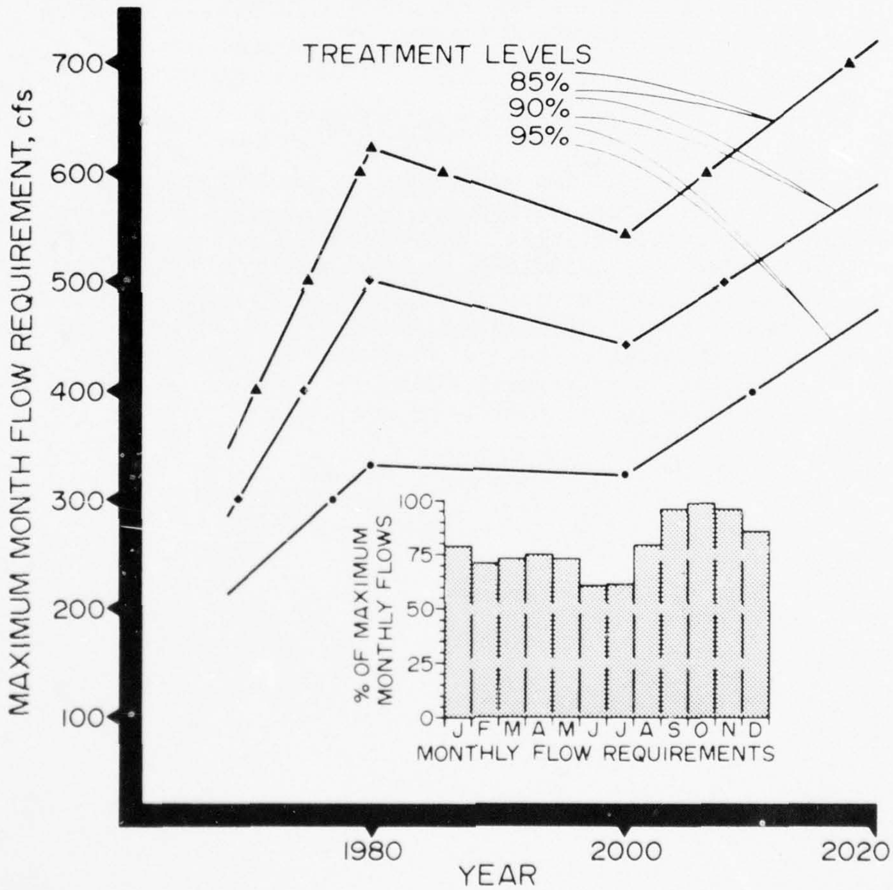

FIGURE 59. Minimum Flow Needs for Water Quality Control, Boise River at Caldwell

Note: Average annual flow is 80 percent of the maximum month flow.

respectively. Flow needs at Boise are based primarily on municipal waste discharges. Needs at Caldwell are based on residual loadings from Boise and on sugar beet and potato processing waste loads from the Nampa-Caldwell area.

Burnt River

A water quality control study conducted by the Public Health Service in connection with a Bureau of Reclamation water resource development investigation in 1966 shows that minimum flows of 5 cfs are needed in Burnt River below Huntington to maintain dissolved oxygen standards criteria. These flows must be essentially free of oxygen-demanding substances, and the dissolved oxygen content must be near saturation values.

Management Practices

Minimum flow needs for water quality control must be considered in planning future hydropower developments, or in altering the operation at existing sites. Future base power demands will be met with thermal installations, and the hydroplants will be used to meet peak loads to the extent possible. Facilities to treat cooling water will be required at all thermal plants in the subregion to prevent the discharge of excess heat to surface waters. Re-regulating reservoirs should be constructed below hydro installations used to meet peak power loads.

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LOCATION MAP

SUBREGION 6

S U B R E G I O N 6

L O W E R S N A K E

INTRODUCTION

The Lower Snake Subregion consists of the drainage area of the Lower Snake River located in southeastern Washington, northeastern Oregon, and central Idaho. The Northern Rocky Mountain terrain, occupying the southern and northeastern parts of the area, is generally mountainous, with deep, narrow valleys. The Columbia Plateau, lying in the northwestern part of the subregion, includes river canyons, basalt plateaus, and the Palouse Hills.

Topography has a strong influence on the climate of the subregion. The slopes of mountainous areas cause many different and distinct micro-climates with wide variations in precipitation and temperature. Summer temperatures vary from cool in the mountains to warm in the lowlands; winters are generally cold and mild, respectively. However, even in the lowlands, extreme cold periods do occur. Extremes of -44° to 109°F. (-42° to 43°C.) have been recorded. The average frost-free growing season is about 150 days. Most of the precipitation falls during the winter, and summers are usually dry. Average annual precipitation ranges from about 7 to 40 inches, depending mainly on the elevation.

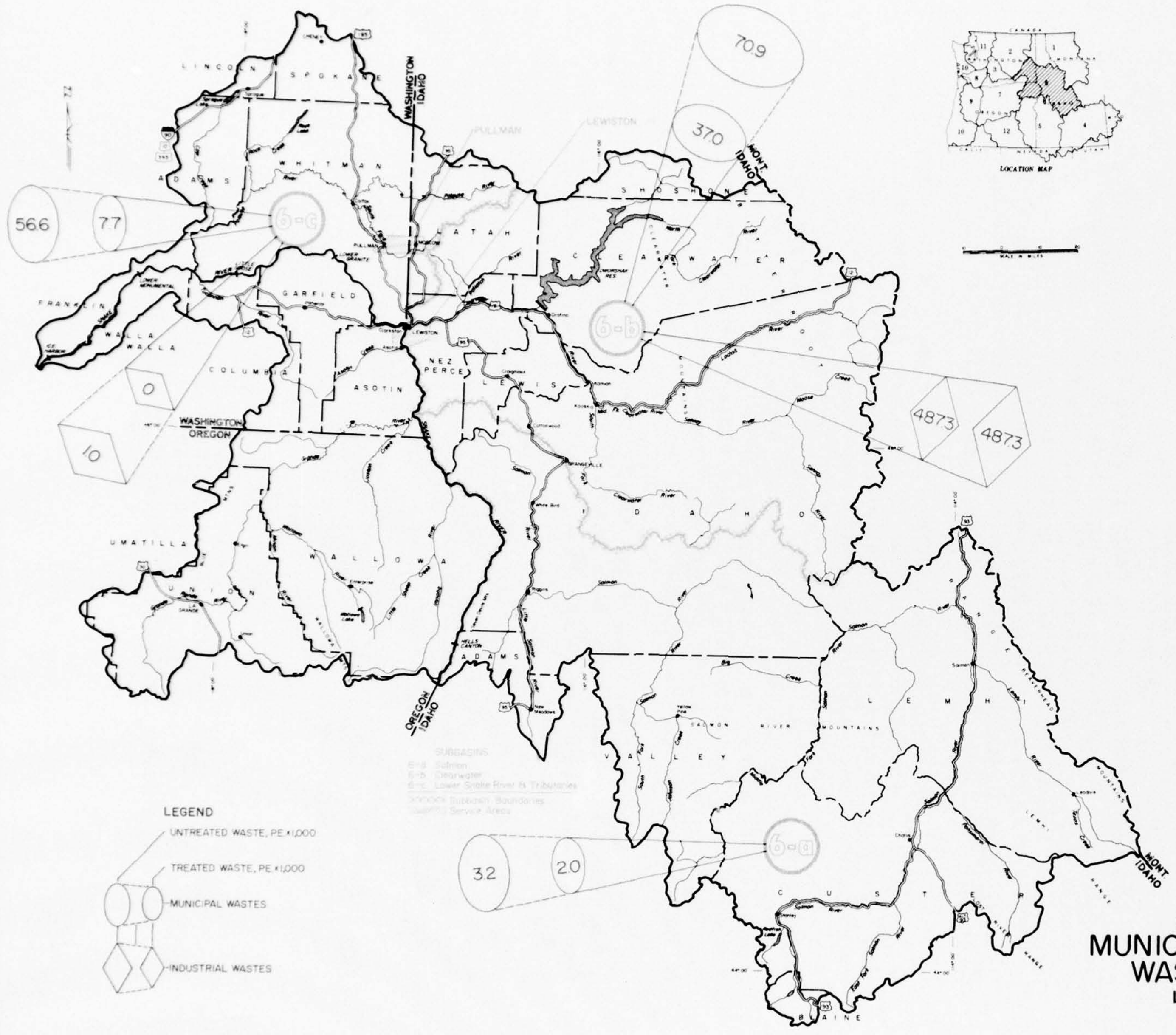
The most important industries are forestry, agriculture, and mining. In recent years, more growth has been achieved in forestry and food processing, while agricultural and mining employment has been declining.

The population in the Lower Snake Subregion in 1965 was about 163,340. The population density averages less than five persons per square mile, compared with more than 20 persons per square mile in the region.

The Lower Snake Subregion (figure 60) is divided into the Salmon, Clearwater, and Lower Snake and Other Tributaries Subbasins. Lewiston and Pullman are the major service areas.

PRESENT STATUS

Municipalities and industries are the largest sources of organic wastes in the Lower Snake Subregion. A graphical summary of municipal and industrial organic waste production and discharge



COLUMBIA-NORTH PACIFIC
COMPREHENSIVE FRAMEWORK STUDY

MUNICIPAL AND INDUSTRIAL WASTES BY SUBBASIN

LOWER SNAKE SUBREGION 6

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FIGURE 60

is also presented in figure 60. The pulp and paper industry accounts for most of the industrial waste loading. Although not reflected in organic waste loadings, sediments resulting from erosion of streambank, channels, and adjacent lands are a major pollution source.

Generally, the surface and ground waters of the subregion are of excellent quality. The only exceptions are usually local bacterial contamination in several stream reaches, and turbidity and sediment problems associated with erosion, accelerated by periods of high runoff. The Snake River also suffers from high seasonal water temperatures and excessive algal production.

Stream Characteristics

The principal tributaries in the Lower Snake Subregion are the Salmon, Grande Ronde, Clearwater, and Palouse Rivers. The Palouse and Clearwater Rivers drain the northern part of the subregion, the former draining the low wheat country of southeastern Washington while the latter drains the high mountains as far east as the Bitterroot Range. As a result, the Clearwater has very heavy and swift runoff from rainfall, as well as considerable snowmelt. The largest river basin in the subregion is that of the Salmon River, which heads at high elevations and is largely supported by snowmelt. The Grande Ronde drains the Wallowa and the Blue Mountains. Floods occur in winter and in early spring. Sustained high flows occur in late spring and summer from melting snows in the higher Wallowas.

Surface-Water Hydrology

The annual streamflow pattern of the Lower Snake River is uniform. High flows occur each year from March through July, and low flows occur normally from August through February. Beginning in March, melting of the mountain snow cover causes the streams to rise. The runoff during the following 3 months, April through June, averages about 55 percent of the annual runoff. During this high-water period, the streams usually attain the peak discharge for the year. The principal factor influencing the seasonal runoff pattern of the tributary streams is the mean elevation of the basins. Most of the Salmon River, South and Middle Fork Clearwater Rivers, and the Imnaha River are at high elevations, and the runoff pattern of these rivers is essentially the same as that of the Snake River. Most of the drainage areas of the North Fork Clearwater and Grande Ronde Rivers are at intermediate elevations. In these drainages, snowmelt runoff occurs earlier, and winter storms cause a greater runoff than in the upper basins.

Table 83 - Average Monthly Discharge, Subregion 6 (12)

	Jan.	Feb.	March	April	May	June	July (CFS)	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
Salmon River near Challis, Idaho	605	602	622	1,338	3,819	4,607	2,158	938	724	754	710	644	1,459
Salmon River at Salmon, Idaho	1,022	1,032	1,075	1,735	4,222	5,366	2,595	1,175	1,006	1,188	1,233	1,105	1,898
Salmon River near French Cr., Idaho	3,320	3,495	4,169	10,303	28,640	30,164	10,837	4,471	3,619	3,984	4,028	8,705	9,233
Salmon River at White Bird, Idaho	3,852	4,041	5,068	12,490	33,429	34,891	12,094	4,967	4,020	4,455	4,582	4,383	10,690
Grande Ronde River at Rondows, Oregon	994	1,483	2,597	4,557	5,662	4,363	1,575	551	497	580	734	1,061	2,044
Selway River near Lowell, Idaho	1,082	1,226	1,974	6,499	14,181	10,642	2,814	833	630	877	1,125	1,305	3,604
Lochsa River near Lowell, Idaho	960	1,018	1,611	5,150	10,540	7,421	1,969	604	463	679	926	1,159	2,712
Clearwater River at Kamiah, Idaho	2,545	2,914	4,899	14,834	29,428	21,286	5,666	1,725	1,340	1,861	2,486	2,981	7,674
Clearwater River at Spalding, Idaho	12,332	11,255	15,000	26,050	36,854	29,632	10,069	4,251	4,366	6,576	9,656	8,326	14,573
Snake River near Clarkston, Wn.	38,505	52,990	63,241	66,968	91,888	80,605	31,565	18,078	20,417	24,959	29,657	31,329	45,850
Palouse River at Hooper, Wn.	838	1,615	1,491	1,250	494	201	75	17	21	51	116	373	545
Snake River below Ice Harbor Dam	39,650	54,464	64,337	65,796	88,618	79,913	32,197	18,570	20,670	25,017	30,447	32,131	45,984

The basins of the Palouse River and the small streams in Washington are much lower than those of the other tributaries. In these areas, the high water season occurs between January and April, because of winter precipitation augmented by snowmelt. Low flows generally occur in the late summer, and some of the lower tributaries in the Palouse River drainage have extended periods of no flow. Table 83 presents monthly discharge data for selected stations in the subregion.

From the standpoint of waste discharge control, the low-flow months from August to February are important. One-in-ten-year low flow is the selected recurrence frequency to predict critical low flows. These data for selected stations are summarized in table 84.

Table 84 - One-in-Ten-Year Low Flows, Subregion 6 (12)

Stream and Location	One-in-Ten-Year Low Flow (cfs) 1/
Salmon River near Challis, Idaho	430
Salmon River at Salmon, Idaho	730
Salmon River near French Creek, Idaho	2,500
Salmon River at White Bird, Idaho	2,900
Grande Ronde River at Rondowa, Oregon	320
Selway River near Lowell, Idaho	400
Lochsa River near Lowell, Idaho	290
Clearwater River at Kamiah, Idaho	800
Clearwater River at Spalding, Idaho	3,100
Snake River near Clarkston, Washington	11,800
Palouse River at Hooper, Washington	<20
Snake River below Ice Harbor Dam	12,600

1/ Period of 1 month.

Impoundments and Stream Regulation

The major impoundments in the Lower Snake Subregion are the Dworshak Dam on the North Fork of the Clearwater River and Hells Canyon, Lower Granite, Little Goose, Lower Monumental Dams, and Ice Harbor on the Snake River. Most dams in the subregion are relatively new, and the effect of impoundments on water quality has not yet been determined; however, several impoundments are expected to significantly alter water quality.

Ground-Water Characteristics

Two aquifer units furnish most of the ground-water supplies in the Lower Snake Subregion. These are the alluvial deposits and the basalt of the Columbia River Group. Each of these is capable of supplying moderate to large yields at favorable locations. However, the abundant quantity of excellent quality surface supplies has limited ground-water development and utilization in most areas.

The alluvial deposits occur as narrow terraces along many streams, and as broad basin fills in some of the headwater valleys of the Salmon River in the southeastern part of the subregion. Because many of the alluvial terrace deposits occur in narrow bedrock valleys, they may be very important local sources of ground-water supply. Generally these deposits are coarse and permeable and will yield moderate to large supplies of water where ten to several tens of feet of material are saturated. Water in the alluvial deposits is generally of suitable quality for all purposes. The water is generally of a calcium bicarbonate type; the dissolved solids are usually less than 250 mg/l; the water is soft to moderately hard and free of troublesome trace elements.

The Columbia River group will yield moderate to large supplies of water where a number of successive flows are penetrated. However, interfingering fine-grained sedimentary strata reduce the permeability at some places. Also, the basalt chiefly underlies high plateaus, such as those in southeastern Washington, and at some places the water table is many hundred feet below the land surface. The waters in this aquifer unit are generally satisfactory for most purposes. The waters are usually of the calcium bicarbonate type, with less than 300 mg/l dissolved solids, and are soft to moderately hard. The SAR is low, rarely exceeding 2.5 mg/l; iron also is usually low; and fluorides seldom exceed 1.0 mg/l.

Pollution Sources

Municipal and industrial waste loadings and discharges, in population equivalents, are summarized by subbasin in table 85 for the Lower Snake Subregion.

At present, municipalities and industries in the subregion produce wastes equivalent to those from a population of 619,050 persons. Of this total, 70 percent is generated by the pulp and paper industry, 21 percent by municipalities, and 9 percent by the food-processing industry. The lumber and wood products industry is considered to be a major pollution source in some areas of the subregion, but no quantitative data are available.

Waste treatment and other means of waste reduction decrease the total organic load to the subregion's waters by only 14 percent, so that about 534,040 population equivalents actually reach waterways. Of this total, 46,740 PE are released by municipalities, and 487,300 PE are discharged by industries.

Improper land use and management practices, mining, and construction operations result in accelerated erosion and high sediment production in several areas. Other sources of pollution in the subregion include wastes from the rural population, irrigation, agricultural animals, recreation, and natural sources.

Municipalities

Salmon Subbasin There are only four communities in the Salmon Subbasin that provide sewage collection systems. These systems serve 3,250 persons, or about 29 percent of the subbasin population. The community of New Meadows operates efficient lagoons, Cobalt has secondary treatment, Challis provides primary treatment, and Salmon has no waste treatment. A total organic load of only 2,030 PE is discharged to subbasin waterways by these facilities. The Idaho Water Quality Standards require that Salmon, the largest waste source, install secondary treatment. The small towns of Riggins and White Bird have no collection or treatment systems.

Clearwater Subbasin There are seventeen communities in the Clearwater Subbasin served by sewage collection and treatment facilities. Of this total, six communities operate secondary treatment plants and six have effective lagoons. Five communities have primary waste treatment, but must upgrade to secondary treatment to satisfy minimum State water quality standards.

Municipal waste sources are concentrated in the Lewiston Service Area, where primary is the prevailing level of waste treatment. A total organic waste load equivalent to that from a population of 34,900 is discharged from the service area. The City of Lewiston accounts for about 30,000 PE. The Idaho Water Quality Standards call for secondary waste treatment at Lewiston by June 30, 1970. In addition, the Washington Water Quality Standards require installation of secondary treatment, disinfection facilities, and proper outfalls at Clarkston and Asotin by March 31, 1970.

Other waste sources in the subbasin are few and scattered. Many small lumbering and agricultural towns dot the subbasin, but the wastes generated by the populations of such towns are insignificant in the presence of the large flows into which they are discharged. Nevertheless, the area exhibits a high level of waste

Table 85 - Summary of Municipal and Industrial Wastes, Subregion 6 1/

	Municipal					Industrial			
	Primary	Secondary	Lagoon	Other	Total	Pulp & Paper	Food Processing	Other	Total
Salmon Subbasin									
Number of facilities	1	1	1	1	4				
Population served	700	500	550	1,500	3,250				
PE produced	700	500	550	1,500	3,250				
PE discharged	400	80	50	1,500	2,030				
% removal efficiency	43	84	91	0	37				
Clearwater Subbasin									
Number of facilities	5	6	6		17	1	3		4
Population served	30,150	5,050	3,700		38,900				
PE produced	61,550	5,650	3,700		70,900	432,000	55,300		487,300
PE discharged	36,130	670	250		37,050	432,000	55,300		487,300
% removal efficiency	41	88	93		48	0	0		0
Lower Snake and Other Tributaries Subbasin									
Number of facilities		10	7	2	19			1	1
Population served		34,540	13,250	1,400	49,200				
PE produced		38,850	16,350	1,400	56,600			1,000	1,000
PE discharged		5,230	1,330	1,100	7,660			0	0
% removal efficiency		86	91	21	86			100	100
Total									
Number of facilities	6	17	14	3	40	1	3	1	5
Population served	30,850	40,100	17,500	2,900	91,350				
PE produced	62,250	45,000	20,600	2,900	130,750	432,000	55,300	1,000	488,300
PE discharged	36,530	5,980	1,630	2,600	46,740	432,000	55,300	0	487,300
% removal efficiency	41	86	91	10	64	0	0	100	0.2

1/ FWPCA inventory of Municipal and Industrial Wastes, Lower Snake Subregion, 1965.

treatment, with waste stabilization lagoons or secondary treatment prevailing at most locations. Only Orofino and Craigmont, Idaho, with primary treatment, have less than adequate treatment. The Idaho Water Quality Standards call for secondary treatment at Craigmont by December 31, 1969, and at Orofino by June 30, 1972.

Lower Snake and Other Tributaries Subbasin The level of municipal waste treatment in this portion of the Lower Snake Subregion is generally high. Seventeen of the nineteen communities with waste collection and treatment systems have secondary waste treatment or waste stabilization lagoons. An overall waste reduction efficiency of 86 percent is accomplished, resulting in an organic load to the subbasin waterways equivalent to that from a population of 7,660.

The largest municipal waste source is in the Pullman Service Area, including the towns of Pullman, Washington, and Moscow, Idaho. Both communities have efficient secondary waste treatment. Moscow discharges an organic load of about 2,100 PE into Paradise Creek, a small tributary which enters the South Fork of the Palouse River near Pullman's city limits; and Pullman discharges about 1,400 PE to the South Fork of the Palouse River. During certain periods of the year, the waste waters from the Moscow and Pullman waste treatment plants constitute the major portion of streamflow in the South Fork.

Existing waste treatment deficiencies in the remainder of the subbasin are minor. However, in the Grande Ronde drainage, the towns of Union and Wallowa, Oregon, are in need of improvements. Failure of many of the individual septic tanks that constitute the waste disposal system of the town of Union indicates that a waste collection and treatment system is required. The town's wastes enter small Catherine Creek, which also receives the secondary waste effluent of LaGrande. A portion of the town of Wallowa is served by a community septic tank. The Oregon Water Quality Standards require that secondary treatment and chlorination be installed by May 1969.

Industries

Salmon Subbasin No data are available concerning industrial waste sources in the Salmon Subbasin. Waste discharges from sawmills are believed to be the most significant. Forest products plants can discharge waste containing wood sugars, floating solids, and other organic materials. Small mining operations along the Salmon River have resulted in localized turbidity problems. Mining of copper on Panther Creek has interfered substantially with the spawning success of anadromous fish.

Clearwater Subbasin Industrial waste treatment in the Clearwater Subbasin is minimal. A total organic load equivalent to that from a population of 487,000 PE is discharged without conventional treatment. The most significant single source of organic wastes in the subregion is an industrial plant in the Lewiston Service Area. A complex of manufacturing operations, the plant includes a large lumber mill, a plywood plant, wood-fabricating facilities, and an integrated pulp, paper, and paper-board mill. The pulp and paper plant provides no treatment of wastes, and available information on plant operations indicates that it has a waste-to-product ratio well above the norm for modern sulfate pulping plants. A total organic load of about 432,000 PE is discharged to the Snake River. The Idaho Water Quality Standards require that this industry provide primary treatment. A pea- and potato-processing plant at Lewiston also discharges without waste treatment. An organic load of about 50,000 PE is discharged to the Clearwater River. The Idaho Water Quality Standards require that primary treatment be installed and connected to the city collection system by June 30, 1970. Two meat-packing plants in Clarkston, Washington, have inadequate waste treatment. The Washington Water Quality Standards call for primary treatment at these plants by March 31, 1970.

Other waste sources in the subbasin are few and scattered. They are limited to grain dumps or sawmill operations. No data are available concerning the nature of these wastes, but they are not considered to be major pollution sources.

Lower Snake and Other Tributaries Subbasin Industrial waste production in this portion of the Lower Snake Subregion is limited, and a high level of treatment is generally practiced. The most significant industrial operations are in the Grande Ronde drainage. However, only minor quantities of wastes reach the area's waterways. A particle board mill at Island City, Oregon, utilizes lagoons; and a plywood mill at Elgin, Oregon, operates land-disposal facilities. A chemical plant at LaGrande, Oregon, disposes of organic waste residues by use of non-overflow lagoons. A sausage company at LaGrande has a septic tank and drain field for treatment of slaughterhouse wastes. A concrete company at LaGrande operates three settling ponds for removal of gravel washings before discharge to the Grande Ronde River. Small mining operations have resulted in turbidity problems in the Upper Grande Ronde River.

Rural-Domestic

Table 86 summarizes by subbasin and subregion that portion of the population served by individual waste disposal systems.

Approximately 44 percent, or 72,000 persons, are classed as rural. The rural population generally depends upon disposal by septic tanks and drain fields. Few problems are associated with the rural population, and those that do result are generally localized.

Table 86 - Summary of Population Served by Individual Waste Disposal Facilities, Subregion 6 1/

Subbasin	Population Served Thousands	Percent of Subregion	Percent of Subbasin
Salmon	8.0	4.9	71.0
Clearwater	28.0	17.1	41.9
Lower Snake and Other Tributaries	36.0	22.0	42.2
TOTAL	72.0	44.0	

1/ Derived as a residual from FPCA Municipal and Industrial Waste Inventory, Lower Snake Subregion, 1965.

Irrigation

Irrigation in the Lower Snake Subregion is limited, particularly when compared with the extensive irrigation use in the Central and Upper Snake Subregions. A total of about 276,000 acres is irrigated in the subregion, requiring an average annual water demand of about 1,095,000 acre-feet. Of this total, it is estimated that about 552,000 acre-feet of water actually return to waterways.

Major areas of irrigation are along the Tucannon River, near the Lewiston Service Area, in the upper Salmon River, and in the Wallowa and Grande Ronde Valleys. Streamflow depletions caused by storage and diversions and irrigation return flows represent minor pollution problems and sources in these areas. However, in the lower reaches of the Tucannon River, the streambed flattens out along an area of plain, where it is heavily drawn upon for irrigation. Depleted and sluggish, the appearance of the Tucannon is reduced by erosion caused by high winds, sharp winter thaws, and bank caving. Even though the stream is burdened by sediment, it is of sufficient chemical quality to support a small salmon run. The only other known problem associated with irrigation is in the headwaters of the Salmon River, which sometimes suffers flow limitations resulting from irrigation withdrawals to limited bench areas.

Agricultural Animals

Agricultural animal waste drainages in the Lower Snake Subregion are a significant source of coliform bacteria and a source of some portion of biochemical oxygen demand. The estimated organic waste potential of the animal population is equivalent to that from a population of 3.2 million people. An estimated 95 percent of the wastes generated are reduced by deposit to the land and natural decomposition, so that about 160,000 PE eventually reach waterways. Grazing and feeding of farm animals are considered to be a major waste source, but their impact on water quality is difficult to determine. The animal population is generally diffused throughout the subregion although concentrations occur along streams in several areas.

Streambank feedlots and dairies are situated at a number of points, providing unrestrained sources of serious bacterial contamination. Less concentrated and significant are pasture and grazing areas along watercourses and drainage ditches. In many areas the streambanks are not even fenced, allowing the animals unrestricted access to the water. Under these conditions, high biochemical oxygen-demanding wastes, coliform bacteria, high levels of nutrients, and solids are flushed into streams from a rain or washing, with significant effects on water quality.

Other Land Uses

Land use and management practices result in a significant source of pollution in the Lower Snake Subregion. The most important related practices are dam construction, road construction, logging, and agriculture.

The Lower Snake River and tributaries are undergoing an unusually active period of dam construction. Such construction could cause excessive turbidity and sedimentation problems, and could threaten salmonid migration if proper control measures are not followed. In general, adequate consideration has been given to such problems during the construction period. Water quality impacts such as turbidity and sedimentation which might occur during dam construction are subject to inspection and control by State and Federal agencies.

Logging, a significant cause of erosion in some forested areas, is not considered to be a major pollution source in the Lower Snake Subregion. Clear cutting is the general practice with some selective cutting found throughout the subregion. Logging-related soil movement is associated primarily with logging road construction.

The most significant pollution resulting from land use and management practices occurs in the agricultural area of the Palouse drainage. The Palouse drainage has the maximum sediment yield of the Pacific Northwest area. Thousands of acres that have been bared by the plow are exposed to strong winds, spring rains, and thaw which move great quantities of the loess topsoil into the streams. The loess soils of the area are extremely susceptible to erosion. The Palouse area has long been a site of soil conservation measures and methods of development, but erosion control measures have, in most cases, been inadequate as applied by the farmer.

Present Water Quality

The quality of waters in the Lower Snake Subregion is generally good; however, there are some problems with low D.O., turbidity, nuisance growth and nitrogen supersaturation. Streams in the Palouse drainage and the Snake River suffer from the most serious water quality degradation.

Main Stem Snake River

Before the Snake River enters the Lower Snake Subregion, Brownlee Reservoir acts as a huge natural settling pond, releasing water that has undergone the natural processes of decomposition of organics, settling of suspended matter, cooling, and bacterial die-off. The water that passes from the dam has been improved within the reservoir; however, it does have a dissolved oxygen deficiency.

Figure 33 presents a generalized dissolved oxygen profile for the Snake River. Dissolved oxygen concentrations of the Lower Snake are usually found to be near the saturation level. However, a dissolved oxygen deficiency exists below Hells Canyon Dam, since dissolved-oxygen-deficient water in the lower levels of Hells Canyon Reservoir, caused by decomposing algae and residual waste loadings, is passed downstream through low-level turbine intakes. During spills, a supersaturated dissolved oxygen content exists; however, the concurrent nitrogen supersaturation results in a toxic condition for fish. The high reaeration rate of the Snake River below Hells Canyon quickly restores the dissolved oxygen to near-saturation levels. High oxygen levels persist in the remainder of the Snake, except for a slight dissolved oxygen depression as a result of waste discharges from the Lewiston Service Area. This depression does not constitute a problem at present, but could be magnified with the filling of the Lower Granite Reservoir.

Biochemical oxygen demand (BOD) is a measure of the oxygen-utilizing potential of organic materials present in water. Figure 34 presents a generalized biochemical oxygen demand profile for the Snake River. The Lower Snake River between Oxbow Dam and the Lewiston Service Area has an average BOD of approximately 2 mg/l, which is considerably higher than the background BOD of 1 mg/l. Since the nearest source of waste loading is over 200 miles up-stream, these BOD levels are higher than would be expected. Heavy algal growths are probably the cause of the high values. The algae exert a demand on the dissolved oxygen as they die off, and the products of decomposition are recycled into the flowing water to again stimulate algal production further downstream. Below the Lewiston Service Area, the BOD increases to over 5 mg/l as the result of waste discharges from the pulp and paper mill, municipalities, and food-processing plants. The BOD then recedes to nearly background levels before the Snake discharges to the Columbia River.

Bacterial quality in the Lower Snake River is generally adequate to support water-contact recreation. Average coliform densities greater than the 1,000 MPN/100 ml limit recommended for water-contact recreation have been found only below the Lewiston Service Area. The bacterial levels do not indicate a serious bacterial pollution problem, but they do represent a potential threat to water-contact recreation users.

Existing water temperature conditions at Ice Harbor Dam (near the confluence with the Columbia River) are influenced by releases from Brownlee Reservoir, and by temperatures of the Salmon and Clearwater Rivers. Temperature effects of the Grande Ronde are reportedly minor. Data indicate that temperature reductions through Brownlee Reservoir of 10°F. (5.6°C.) are common during July and August. Fall temperatures, however, are increased by about 6°F. to 8°F. (3°C. to 4°C.). These conditions are a result of low-level releases from Brownlee Reservoir, which stratifies during the summer months. Cold water reserves at lower levels are depleted during these months; consequently, waters available for release in the fall have been subjected to atmospheric warming and are of higher than ambient temperatures.

The temperatures of the Snake River at Ice Harbor Dam are lower than at Oxbow Dam for all but 2 months of the year because of cool water discharges from the unregulated Salmon and Clearwater Rivers. Their low temperatures and large discharges have a depressing effect on Snake River temperatures at their respective confluences. However, at Ice Harbor Dam, September and October temperatures of 65° to 70°F. (18° to 21°C.) have been experienced because of the high temperature releases from Brownlee Reservoir and the relatively smaller influences of the Salmon and Clearwater

Rivers during these months. It is estimated that the interaction of Brownlee Reservoir releases with tributary inflows has, in an average year, reduced the maximum summer temperatures at the mouth of the Snake River from 81° to 76°F. (27° to 24°C.); reduced maximum month, mean temperatures from 74° to 71°F.; and moved the month of maximum temperature from July to August.

Sediment and high turbidity caused by runoff from eroded upland fields and the flushing action of spring floods are a major water quality problem in the Lower Snake Subregion. The maximum concentration of sediment observed in the Lower Snake River has been 4,320 mg/l at its confluence with the Columbia River.

The dissolved solids concentration of the Snake River as it enters the subregion is in excess of 300 mg/l. The average dissolved solids concentration of both the Grande Ronde and Salmon Rivers as they enter the Snake River is about 100 mg/l. Because the combined flows of these two tributaries make up more than 40 percent of the Snake below their confluence, they have a considerable diluting effect on the Snake River. Monthly samples collected from the Snake River near Clarkston, below the Grand Ronde and Salmon Rivers, showed an average dissolved solids concentration of about 200 mg/l. The water of the Clearwater River is even lower in dissolved solids than the Salmon and Grande Ronde Rivers and reduces the level in the Snake to about 150 mg/l. Other tributaries entering the Snake River have little effect on the dissolved solids level because their flows are relatively small when compared with that of the main stem.

Figure 36 presents a generalized total phosphate profile for the Snake River. Phosphate levels are significantly reduced in Brownlee Reservoir before the Snake enters the subregion. However, phosphate concentration remains significantly above the minimum level for stimulation of algal growths (0.03 mg/l PO_4 as P). The inflows of the Salmon, Grande Ronde, and Clearwater Rivers act to reduce concentrations, but it appears that the waters of the Snake system above the Clearwater are naturally rich in phosphates, as indicated by the correlation of material transmission rates with flow. Nitrate concentrations are not excessive at all times, but are usually above the threshold value of 0.30 mg/l, at which excessive algal productivity can be expected.

Over the years, the water pollution surveillance station at Wawawai has recorded high levels of plankton productivity. In addition, the presence of floating aquatic slimes has been recently observed in the upper and central areas of the Snake. The unsightly water weeds are prevalent from Oxbow Dam to the mouth of the Clearwater, restricting both boating and the sport fishery of the Snake River above Lewiston.

Tributaries

The quality of tributaries in the Lower Snake Subregion varies. The mountain streams--the Grande Ronde, Salmon, and Clearwater Rivers--tend to be of high physical and chemical quality although some turbidity problems and nuisance growths have been observed. The Tucannon and Palouse Rivers, which flow through agricultural lands, are usually warm, high in sediment, and more mineralized.

Dissolved oxygen levels tend to be high in tributaries, and relatively few related problems exist. Flows in the South Fork of the Palouse River are seasonally depleted to the point that waste discharges constitute the major portion of the river, and it is suspected that an oxygen deficiency results.

As in other subregions of the Snake River drainage, bacterial densities vary considerably with unsuitable conditions occurring below a number of communities. The Palouse and Tucannon Rivers have exhibited the highest coliform counts. In the Tucannon River near Delaney the average coliform count has been about 51,000 organisms/100 ml, and the maximum observed count has been 240,000 organisms/100 ml. The Palouse River near Hooper has an average coliform density of about 9,100 organisms/100 ml, with a maximum of 110,000 organisms/100 ml. These levels are considerably above the limit (1,000 organisms/100 ml) to render streams unsuitable for water-contact recreation.

Sediment results in turbid conditions at many points in the Lower Snake Subregion. In spring, turbidity is particularly noticeable in the Palouse, Grande Ronde, and Tucannon Rivers and Asotin Creek. During periods of high runoff, sediment concentrations reach objectionable levels throughout the subregion. Maximum concentrations of sediment observed in some streams have been 309,000 mg/l in Deadman Creek, 193,000 mg/l in the Tucannon River, 66,400 mg/l in the Palouse River, 80,000 mg/l in the South Fork of the Palouse River, and 433 mg/l in the Clearwater River. The highest observed concentrations occurred during the flood of December 1964.

Between the point where the Snake River enters the subregion and its confluence with the Columbia River, five major tributaries affect mineralization of the river. The Salmon River in central Idaho flows through sparsely populated mountainous areas. Most of this area is underlain by volcanic and intrusive rocks which are resistant to solvent action. Heavy precipitation, high runoff, and the resistant rocks result in waters of very low dissolved solids content. With the exception of the Pahsimeroi and Lemhi Rivers, which drain areas containing limestone and

which are more highly mineralized (200 to 300 mg/l dissolved solids), all streams sampled have contained less than 100 mg/l dissolved solids. The mineral quality of the Grande Ronde River and its major tributary, the Wallowa River, is very similar to that of the Salmon River. The headwaters contain calcium bicarbonate waters of less than 75 mg/l dissolved solids. Use of the water for irrigation in the Grande Ronde and Wallowa Valleys causes some downstream increase in mineralization, but the chemical composition of the water is not changed appreciably. The waters are still of the calcium bicarbonate type with slightly larger amounts of sodium and sulfate. The average dissolved solids concentration of both the Grande Ronde and Salmon Rivers as they enter the Snake River is about 100 mg/l. The water of the Clearwater River is even less mineralized than that of the Salmon River, averaging about 33 mg/l dissolved solids at the mouth. The two principal tributaries between the Clearwater River and the mouth are the Palouse and Tucannon Rivers. These two tributaries flow through a part of the relatively flat Columbia Plateau and are more highly mineralized than other tributaries. The Palouse River averages about 170 mg/l dissolved solids at the mouth.

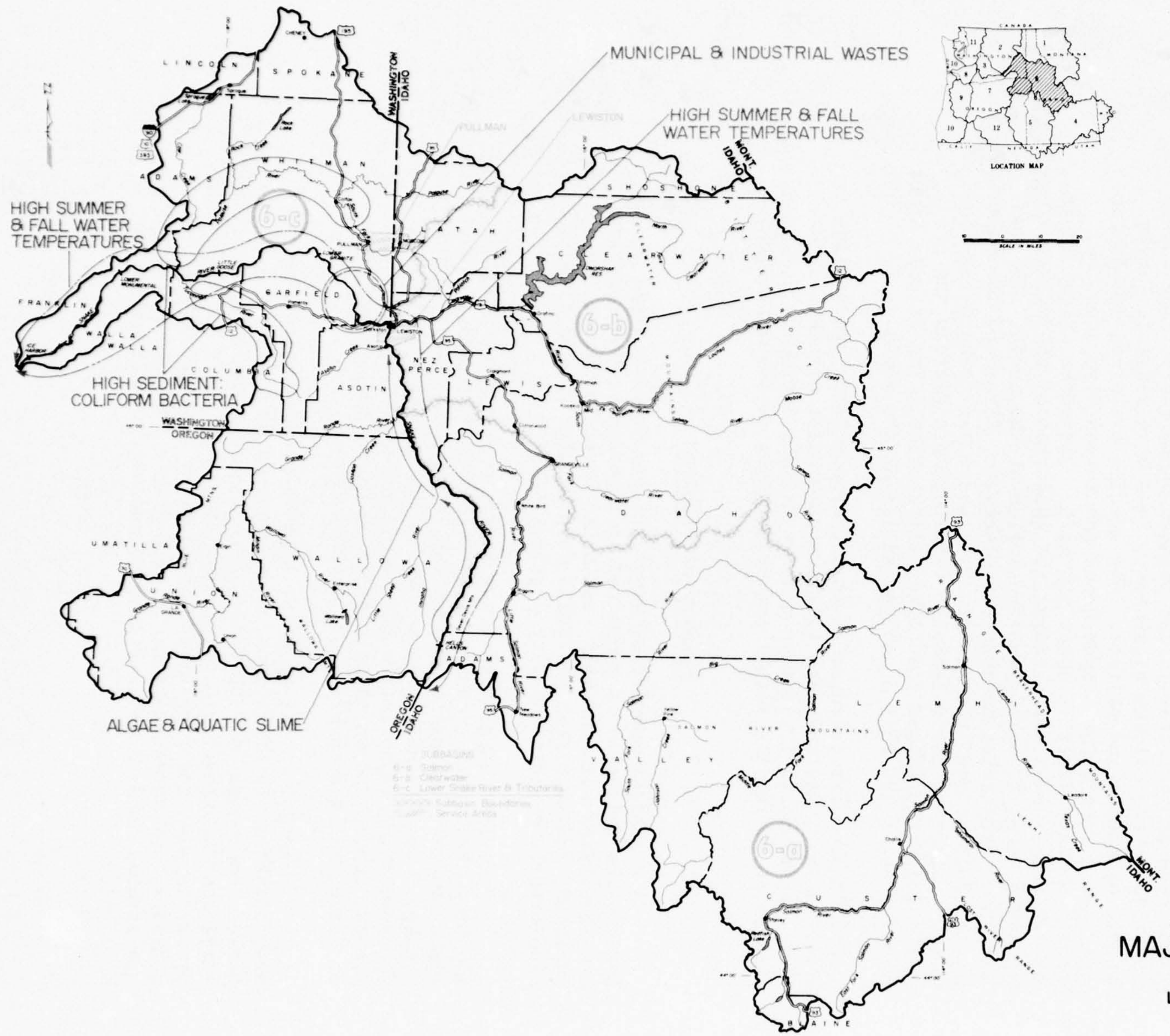
In some irrigated areas in the Grande Ronde and Wallowa River valleys, drainage and alkali accumulation problems occur. Large increases in irrigation use are being prefaced by thorough studies to define the extent and seriousness of these problems.

Summary of Problems

A graphical summary of water quality problem areas in the Lower Snake Subregion is presented in figure 61. Most problems are associated with the main stem Snake River, although the Tucannon, and main stem and South Fork of the Palouse Rivers also experience water quality degradation.

Dissolved oxygen-deficient water in lower levels of Brownlee and Oxbow Reservoirs, caused by decomposing algae and residual waste loadings, is passed downstream through low-level turbine intakes. Because Hells Canyon Dam inundates and greatly reduces the reaeration capabilities of some 25 miles of fast-flowing stream, conditions which existed below Oxbow Dam are suspected of having shifted to below Hells Canyon Dam.

In recent years, floating aquatic slimes, stimulated by high nutrient concentrations, have appeared in the Snake River between Oxbow Dam and the Clearwater River during low-flow periods. These aquatic growths interfere with boating, sport fishing, and other recreational uses of the Snake River above Lewiston. In addition, untreated waste discharges from a pulp and paper mill and several food-processing plants, and waste waters from the



COLUMBIA-NORTH PACIFIC
COMPREHENSIVE FRAMEWORK STUDY
MAJOR WATER QUALITY PROBLEM AREAS
LOWER SNAKE SUBREGION 6

1969

FIGURE 61

Clarkston and Lewiston primary waste treatment facilities render a portion of the Snake River below the service area unsuitable for water-contact recreation.

Perhaps the greatest threat to salmonid fish in the Snake River system, other than physical barriers which block and/or retard fish migration, is high water temperatures. High temperatures (70° to 80°F.) (21° to 27°C.) in the Snake during the summer and fall months stress all salmonid species, but have a particularly adverse effect on upstream migrants which have already been subjected to above desirable temperatures in the Columbia River.

The Tucannon and main stem and South Fork of the Palouse Rivers carry heavy sediment loads, particularly during periods of maximum runoff (winter and early spring). This results mainly from lack of use of adequate soil conservation practices on the highly erosive loess topsoils characteristic of the area, but streambank and channel erosion is also important. In addition, bacterial densities in these rivers are above limits recommended for water-contact recreation.

Nitrogen supersaturation is a severe problem in the Snake River throughout the subregion and has resulted in several fish kills due to gas-bubble disease. The saturation phenomenon, especially its persistence throughout the Lower Snake, is not well understood as yet; however, a special study is underway to determine its cause and to recommend possible solutions.

FUTURE WATER QUALITY MANAGEMENT NEEDS

Based on the projected economic development of the Lower Snake Subregion, the population is expected to increase from 163,340 in 1965 to 274,300 in 2020. This represents an increase of only 68 percent for the subregion, compared with 121 percent for the region.

Figure 62 shows the projected population growth by subbasin for the years 1980, 2000, and 2020. The projected subbasin and service area populations are presented in table 87 by municipal and rural categories. By 2020, over 40 percent of the subregion population will be located in the Lewiston Service Area, and 16 percent will be concentrated in the Pullman Service Area. The remaining population will be scattered throughout the subregion, with concentrations at communities such as Orofino and Salmon, Idaho; LaGrande, Oregon; and Pomeroy, Washington.

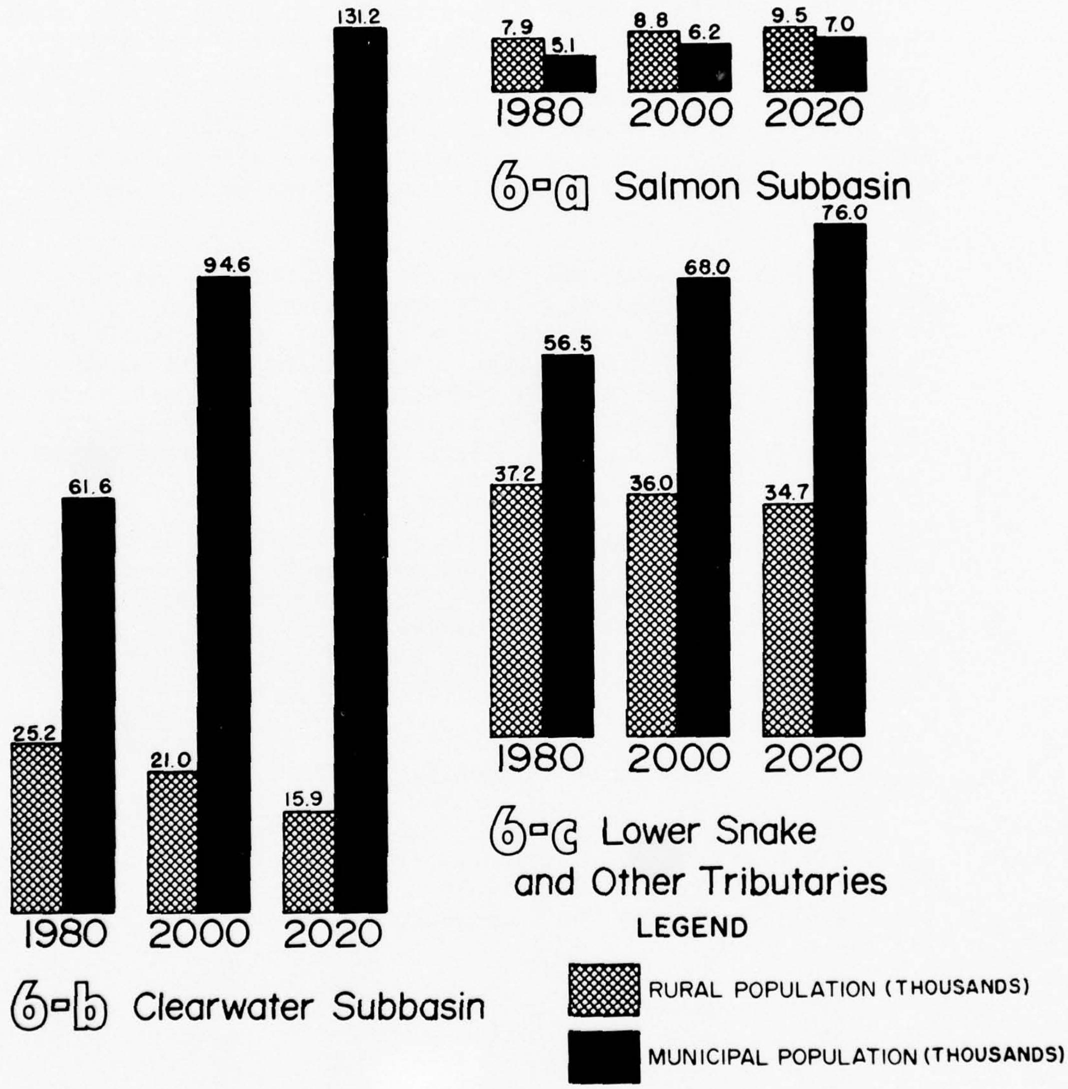


FIGURE 62. Projected Population, Subregion 6

Table 87 - Projected Population, Subregion 6 1/

	1980	2000	2020
		(Thousands)	
Salmon Subbasin	13.0	15.0	16.5
Municipal	5.1	6.2	7.0
Rural	7.9	8.8	9.5
Clearwater Subbasin	86.8	115.6	147.1
Lewiston Service Area	54.8	82.0	112.6
Municipal	46.8	78.0	112.6
Rural	8.0	4.0	-
Other	32.0	33.6	34.5
Municipal	14.8	16.6	18.6
Rural	17.2	17.0	15.9
Subtotal	86.8	115.6	147.1
Municipal	61.6	94.6	131.2
Rural	25.2	21.0	15.9
Lower Snake and Other Tributaries	93.7	104.0	110.7
Pullman Service Area	30.5	38.0	43.4
Municipal	29.8	38.0	43.4
Rural	0.7	-	-
Other	63.2	66.0	67.3
Municipal	26.7	30.0	32.6
Rural	36.5	36.0	34.7
Subtotal	93.7	104.0	110.7
Municipal	56.5	68.0	76.0
Rural	37.2	36.0	34.7
Total Subregion	193.5	234.6	274.3
Municipal	123.2	168.8	214.2
Rural	70.3	65.8	60.1

1/ Derived from Economic Base and Projections, Appendix VI, Columbia-North Pacific Framework Study, January 1971, and from North Pacific Division Corps of Engineers data. Differences between totals in this table and source are due to differences in subregion boundaries. The source is based on economic boundaries and this table is based on hydrologic boundaries. The municipal population is defined as that population discharging wastes to a municipal sewerage system. The rural population is defined as the residual.

Future industrial growth will continue to be based on the subregion's forest and agricultural resources. Pulp and paper processing will continue to dominate in the production of organic wastes, food processing will experience somewhat greater growth, and the organic wastes produced at lumber and wood products industries will remain at about present levels.

Future Waste Production

Municipal

The projected municipal raw waste production for the Lower Snake Subregion is presented in table 88. The portion of the subregion's population served by municipal waste collection and treatment systems is expected to increase from 56 percent in 1965 to 78 percent by the year 2020. It has been assumed that the entire population of the two major service areas will be served by municipal systems at that time.

Table 88 - Projected Municipal Raw Organic Waste Production 1/
Subregion 6

	1970	1980	2000	2020
		(1,000's P.E.)		
Salmon Subbasin	4.5	6.4	7.8	8.8
Clearwater Subbasin	58.1	77.0	118.2	164.0
Lewiston Service Area	50.2	58.5	97.5	140.8
Other	7.9	18.5	20.7	23.2
Lower Snake and Other Tributaries	64.5	70.6	85.0	95.0
Pullman Service Area	33.3	37.2	47.5	54.2
Other	31.2	33.4	37.5	40.8
Total Subregion	127.1	154.0	211.0	267.8

1/ A factor of 1.25 was applied to the municipal population components to account for the effects of small commercial establishments and other urban activities which add to municipal waste loads.

The two major service areas are expected to produce 73 percent of the subregion's municipal waste loading in 2020, as compared with 56 percent in 1965. The Lewiston Service Area will account for over one-half of the total subregion municipal waste production by 2020.

Industrial

Projected raw organic waste loadings for the major industrial categories are presented in table 89 for the years 1980, 2000, and 2020. By the end of the projection period, it is expected that industries will contribute three-fourths of the subregion's total organic waste loading. The pulp and paper industry will continue to be the largest organic waste source, contributing approximately 81 percent of the industrial waste production. The food-processing industry will remain a major source of organic wastes, contributing almost all of the industrial wastes produced by other than pulp and paper production.

It is assumed that future growth will occur at existing operations for most industries. Based on that assumption, all of the pulp and paper and food-processing waste increases will occur in the Lewiston Service Area. Growth in the wood and lumber products industry will take place in the Lower Snake and Other Tributaries Subbasin.

Table 89 - Projected Industrial Raw Organic Waste Production 1/
Subregion 6

	1970	1980	2000	2020
		(1,000's P.E.)		
Pulp and Paper	462.3	523.0	596.0	675.0
Food Products	70.9	102.0	141.0	155.0
Lumber & Wood Products	1.1	1.2	1.3	1.2
TOTAL	534.3	626.2	738.3	831.2

1/ Base data from FWPCA inventory of municipal and industrial wastes, Lower Snake Subregion, 1965.

Rural-Domestic

The projected rural-domestic waste production is summarized in table 90 for the years 1980, 2000, and 2020. The rural-domestic waste production was assumed to be equal to the rural population component shown in table 87. For most areas in the subregion, the rural waste production is expected to remain relatively constant or to decrease slightly. However, the Salmon Subbasin shows some increase in rural waste production.

Table 90 - Projected Rural-Domestic Raw Organic Waste Production, Subregion 6

	1970	1980	2000	2020
		(1,000's P.E.) 1/		
Salmon Subbasin	7.9	7.9	8.8	9.5
Clearwater Subbasin	27.1	25.2	21.0	15.9
Lower Snake and Other Tributaries	36.4	37.2	36.0	34.7
Total Subregion	71.4	70.3	65.8	60.1

1/ Interpolated from 1965 data and 1980 projections.

Septic tanks and some type of subsurface drainage systems are the most likely method to be used to dispose of wastes from individual residences in the future. No widespread problems are anticipated from this source in the future, although corrective measures may be necessary in areas bordering lakes and streams, or where the water table is high.

Irrigation

Approximately 276,000 acres of land are presently being irrigated in the subregion. By 2020, an additional 494,000 acres of irrigated land, and supplemental water supplies for 127,000 acres now under irrigation will be required to meet projected food and fiber needs. About 1,095,000 acre-feet are diverted annually from surface waters to serve the presently irrigated land. By 2020, an estimated farm delivery requirement of 2,270,000 acre-feet will be needed to meet the present irrigation needs, supplemental water needs, and future new irrigation needs.

Irrigation-related water quality problems are minor in most of the subregion at present. Depleted flows and waters degraded by irrigation waste waters result from irrigation operations in the Tucannon, Grande Ronde, and upper Salmon Rivers at present. Potential irrigation development may tend to worsen conditions in these critical areas, and could cause problems in waters not presently affected by irrigation operations.

Other Land Uses

Projections of land use in the subregion, by major types of use, are shown in table 91. The projections show a decrease in land area for forest of approximately 1.5 percent by the year 2020. In contrast, the wood consumption demand by the forest

products industry is expected to increase 21 percent during the same period. The potential for erosion and stream damage will be greater as more intensive harvesting methods are employed by forest users. Increased sediment loads for adjacent streams may result.

Table 91 - Projected Land Use, Subregion 6 1/ (5) (8)

	1966	1980	2000	2020
		(thousand acres)		
Land Use				
Cropland	3,078	3,058	3,046	3,035
Irrigated	(268)	(432)	(531)	(743)
Nonirrigated	(2,810)	(2,626)	(2,515)	(2,292)
Forest	13,537	13,492	13,436	13,380
Range 1/	5,042	5,040	5,038	5,036
Other 2/	714	763	823	882
Total	22,371	22,353	22,343	22,333

1/ Does not include forest range.
2/ Includes barren land, roads, railroads, small water areas, urban and industrial areas, farmsteads, airports, etc.

Improved land use and management practices are badly needed in many areas of the subregion to reduce soil erosion. One of the highest sediment yields in the entire Pacific Northwest has been recorded for the Palouse drainage. Other problem areas are the Grande Ronde Valley and lower Tucannon River Valley.

Use of fertilizers on new agricultural lands will likely add to nutrient levels occurring in the subregion's surface waters and aggravate eutrophication problems that are already quite severe in some areas. Pesticides and herbicides applied to these lands also drain into the water bodies and build up to toxic concentrations in higher levels of aquatic life residing in the water. However, by restricting the use of pesticides and instituting better management practices in the use of fertilizers, pesticides, and herbicides on all lands, water quality degradation from these sources could be minimized.

Agricultural Animals

The raw organic waste production by the livestock population in the subregion is expected to be equivalent to that from a population of 4,200,000 in 1980; 5,600,000 in 2000; and 7,400,000 in 2020. This would account for approximately 86 percent of the total raw organic waste production for the subregion

by the end of the projection period. It is estimated that about five percent of these wastes generated by a normally distributed animal population eventually reach the waterways. This is not the case, however, where large numbers of animals are concentrated in small spaces as they are in feedlots and dairies. The potential for pollution from these sources is high, particularly at those operations which are located along streambanks. Economical methods of control and disposal of feedlot wastes need to be developed and applied to all operations bordering surface waters. It may be necessary to treat wastes produced at other locations where the potential for ground-water pollution is high.

Concentrations of animals now situtated on the Snake River above Lewiston and in the Grande Ronde Valley are expected to increase in the future, with accompanying waste control problems.

Recreation

As the demand for water-based recreation continues to outpace population growth, the wastes resulting from these activities are expected to continue increasing at a rapid rate. Construction and expansion of adequate waste disposal facilities at recreation areas must keep pace with the increased recreational use to prevent water pollution from this source. The following summary of projected raw waste production by recreation activity gives an indication of the amount of future construction that will be required:

Year	Population Equivalents 1/
1970	43,500
1980	59,000
2000	108,500
2020	200,500

1/ Bureau of Outdoor Recreation and U.S.D.A. Forest Service Projections for total man recreation days (TMRD).

The series of reservoirs on the Snake River, and streams in the Salmon and Clearwater drainages will receive heavy recreational use by the end of the projection period. Lower Granite and Ice Harbor Reservoirs are expected to receive particularly heavy use.

Other Factors Influencing Quality

The growths of unsightly algae that occur annually in basin streams are a serious water quality problem that detract from most water uses, particularly fishing and recreational pursuits. These growths have been quite troublesome on Snake River in the past. Algal growths flourish in impounded waters where water temperatures are maximum and water circulation is minimum. Completion of the series of pools under construction on the Snake River below Lewiston is expected to add to the algal growth problem.

The location and operation of hydropower installations will have more impact on future water quality conditions in the Lower Snake Subregion than will the management of all other sources of water quality degradation. Construction of High Mountain Sheep, Asotin, and Lenore Dams could seriously degrade quality of the Lower Snake, which would reduce or eliminate the Snake River's anadromous fish runs.

Dworshak Dam will have a selective withdrawal structure designed to help maintain adequate water quality downstream. Use of the selective withdrawal system will make it possible to improve water temperature conditions during the late summer and fall. Catherine Creek and Grande Ronde projects are being studied to determine if by the use of selective withdrawal they can enhance the downstream water quality conditions. At present it looks as if these projects can be regulated to benefit the downstream water quality.

Quality Goals

Quality goals are based on State water quality standards criteria established for the subregion waters. Water quality standards for Idaho, Oregon, and Washington apply to portions of the subregion. The standards of all three States contain two provisions that are critical to the maintenance of high quality water; one, the antidegradation provision which ensures that waters whose existing quality is better than the established standards will be maintained at that high quality and; two, the provision that the highest and best practicable treatment under existing technology will be applied to all waste discharges. Water quality standards are discussed by states in the Regional Summary.

The uses and criteria presented in this Regional Summary apply generally to the waters of the subregion, but water quality standards documents should be consulted for information on

specific waters. A complete set of each State's water quality standards is available upon request from the following State agencies: Idaho Department of Health; Oregon State Department of Environmental Quality; and Washington Water Pollution Control Commission.

MEANS TO SATISFY DEMANDS

Controlling pollution in the Lower Snake Subregion to maintain high water quality to adequately serve the river system's functions will require a coordinated program of waste reduction, flow regulation, application of waste-controlling techniques, and development of a system of cooperative management of the watershed for pollution control. Management of hydropower installations will be of major importance.

Waste Treatment

Future Waste Discharges

Based on the treatment levels and raw waste projections presented earlier, the projected municipal waste loadings to be discharged to waters of each subbasin are shown in table 92. The industrial waste loadings for major industrial categories are presented in table 93. The total municipal and industrial organic waste loading is expected to be 130,100 PE in 1980; 107,000 PE in 2000; and 125,400 PE in 2020.

Table 92 - Projected Municipal Organic Waste Discharges, Subregion 6

	1980	2000	2020
		(1,000's P.E.)	
Salmon Subbasin	0.9	0.8	0.9
Clearwater Subbasin	11.6	11.8	16.4
Lewiston Service Area	8.8	9.7	14.1
Other	2.8	2.1	2.3
Lower Snake and Other Tributaries	10.6	8.5	9.5
Pullman Service Area	5.6	4.8	5.4
Other	5.0	3.7	4.1
TOTAL	23.1	21.1	26.8

Table 93 - Projected Industrial Organic Waste Discharges, Subregion 6

	1980	2000	2020
		(1,000's P.E.)	
Pulp and Paper	78.4	59.6	67.5
Food Products	15.3	14.1	15.5
Lumber and Wood Products	0.2	0.1	0.1
TOTAL	93.9	73.8	83.1

By 2020, 73 percent of the municipal waste load is expected to originate in the Lewiston and Pullman Service Areas. The remaining municipal waste load will be scattered among the numerous small communities in the subregion. LaGrande, Oregon, which had a 1960 population of 12,000, is the largest town outside the two major service areas.

The largest organic loads, representing 61 percent of the total municipal and industrial loads produced by 2020, will stem from pulp and paper processing activities. The pulp and paper production load is generated at the Potlatch Forests plant located in the Lewiston Service Area. All the growth in this industry and most of the growth in food-processing operations are expected to take place in the Lewiston Service Area.

Treatment Costs

The water quality standards implementation plans call for installation of secondary treatment facilities for all municipal and industrial waste discharges in the near future. Deadlines for completion of these facilities vary with individual cases, but the last facility should be completed by 1973. The costs associated with construction and operation of municipal treatment plants for various levels of treatment are presented in figures 4 and 5 in the Regional Summary.

Other Pollution Control Practices

Improved land management practices are badly needed in the Palouse Basin to reduce the enormous amount of sediment transported from the drainage. The recommended control measures relative to fertilizer and pesticide control are also of particular concern in this basin.

Algae control methods must be developed to alleviate conditions that now exist throughout the lower Snake River. The unsightly algal growths seriously detract from many uses of lower Snake waters and will become more troublesome with completion of the reservoirs below Lewiston. Research and study into methods of algae control are perhaps the greatest water quality control need in Subregion 6.

Department of the Interior studies conducted in 1968 concluded that the temperature of lower Snake River waters could be controlled with a properly managed high dam at the Appaloosa site. However, other factors such as low dissolved oxygen levels and high dissolved nitrogen levels below the dam detract from the attractiveness of this undertaking unless specific control measures are applied. Additional detailed water quality studies should precede authorization and licensing of any dam in the middle Snake reach.

Multiple-level outlets are installed in Dworshak Dam which permit flexibility in water temperatures below the dam. Proper use of the outlets can have a favorable effect on the water quality of the lower Clearwater River and, possibly, the lower Snake River.

Minimum Flow Requirements

Since waste treatment cannot be applied to noncollectable wastes and does not economically remove all contaminants from collectable wastes, a certain amount of streamflow is necessary for dilution and assimilation of residual wastes reaching the streams. Generalized curves showing minimum flow requirements for raw waste loadings subjected to various treatment levels are presented in figures 63 through 65. These figures give approximate requirements based on dissolved oxygen standards criteria only for small to middle-sized communities located on tributary streams. Figures 63 and 64 are based on minimum dissolved oxygen concentrations allowable at seasonal low. In those locations where existing quality is above the minimum established in the water quality standards documents, the antidegradation provision applies. Figure 65 presents estimated minimum flow needs for various treatment levels at locations where this provision applies. The curves may also be used to indicate ranges of flows needed to assimilate industrial or agricultural wastes, although they were developed primarily for application to municipal waste discharges. The areas to which individual curves apply are delineated in figure 66.

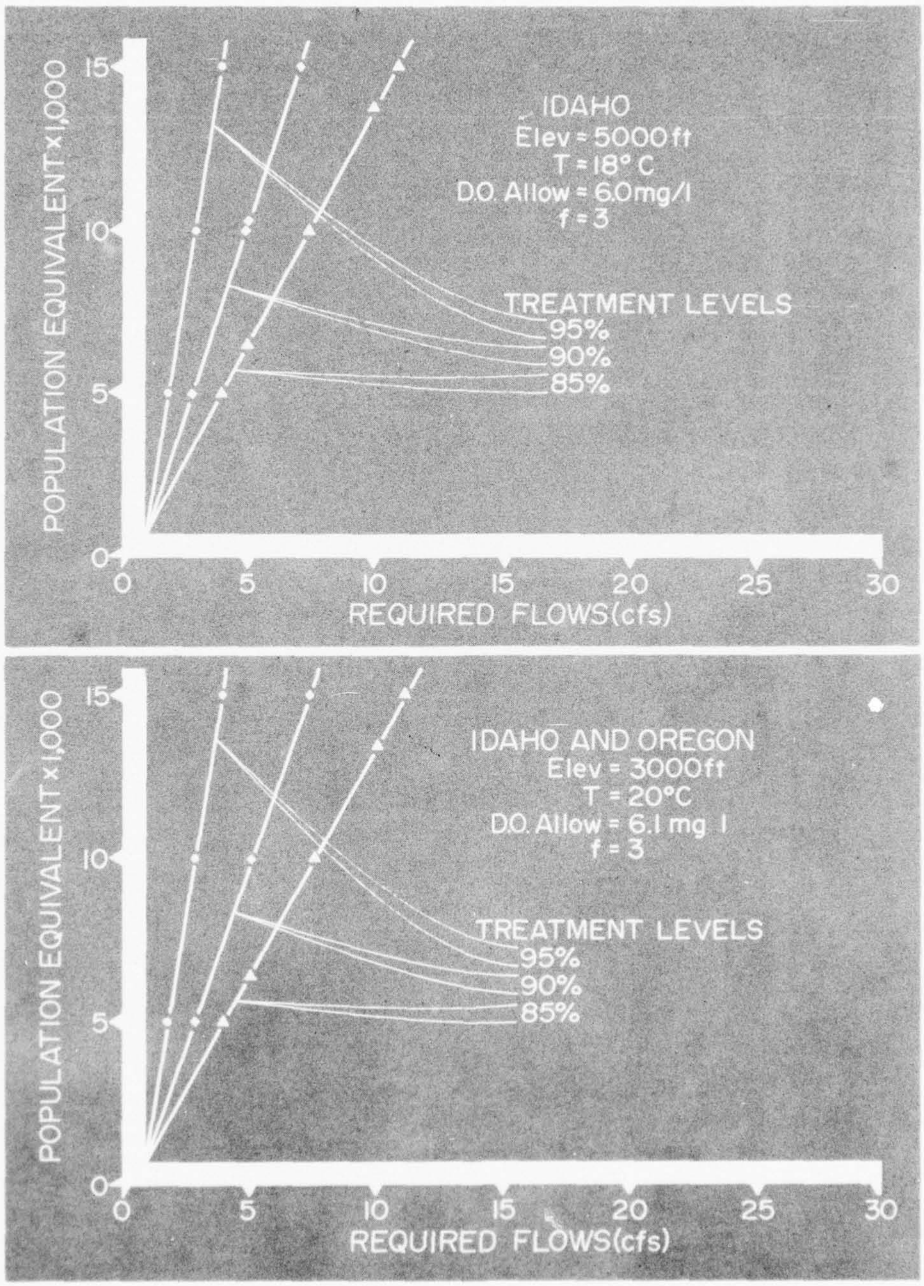


FIGURE 63. Minimum Flow Needs to Maintain Idaho and Oregon Dissolved Oxygen Standards Criteria (Elevations 5000 and 3000 feet)

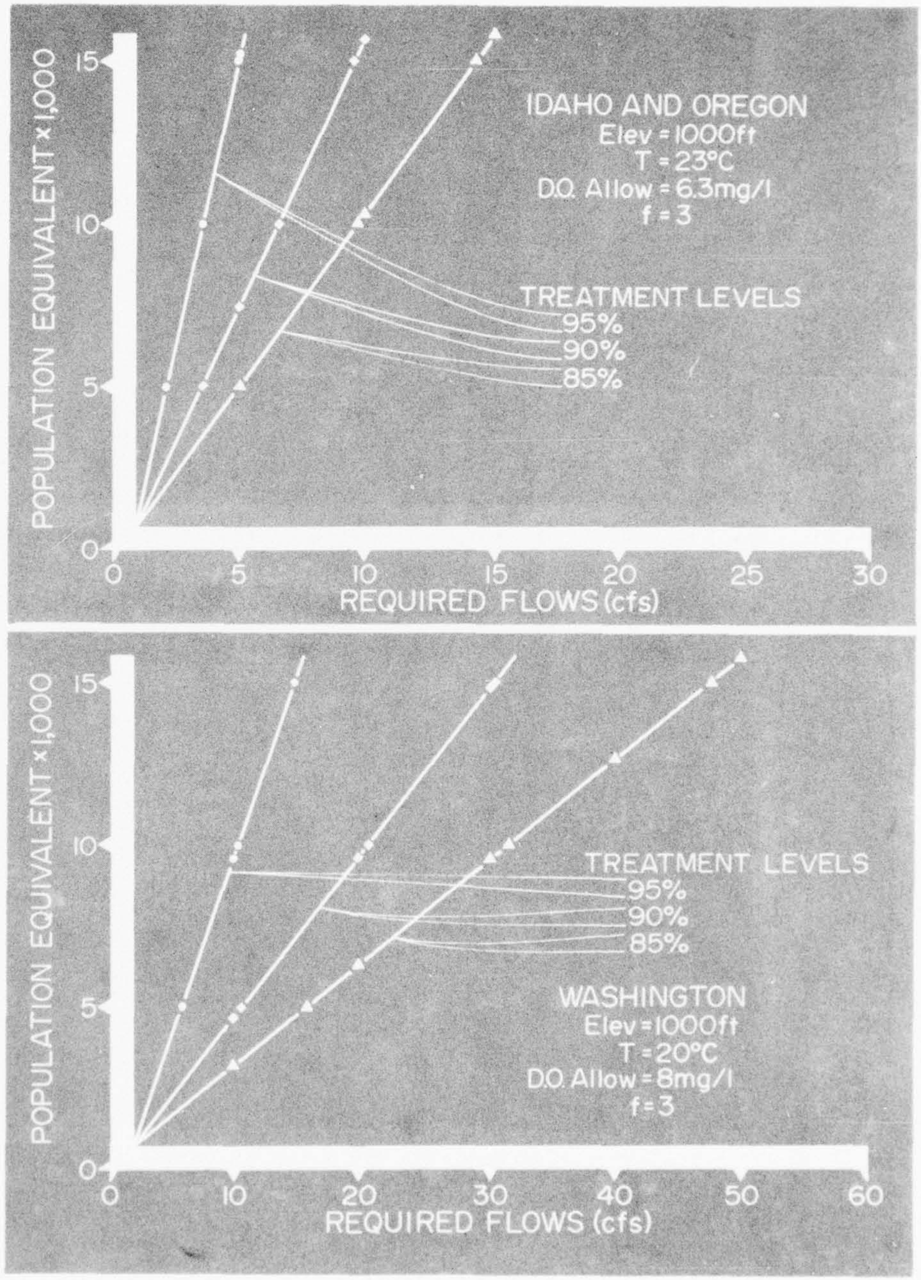


FIGURE 64. Minimum Flow Needs to Maintain Idaho, Oregon, and Washington Dissolved Oxygen Standards Criteria (Elevation 1,000 Feet)

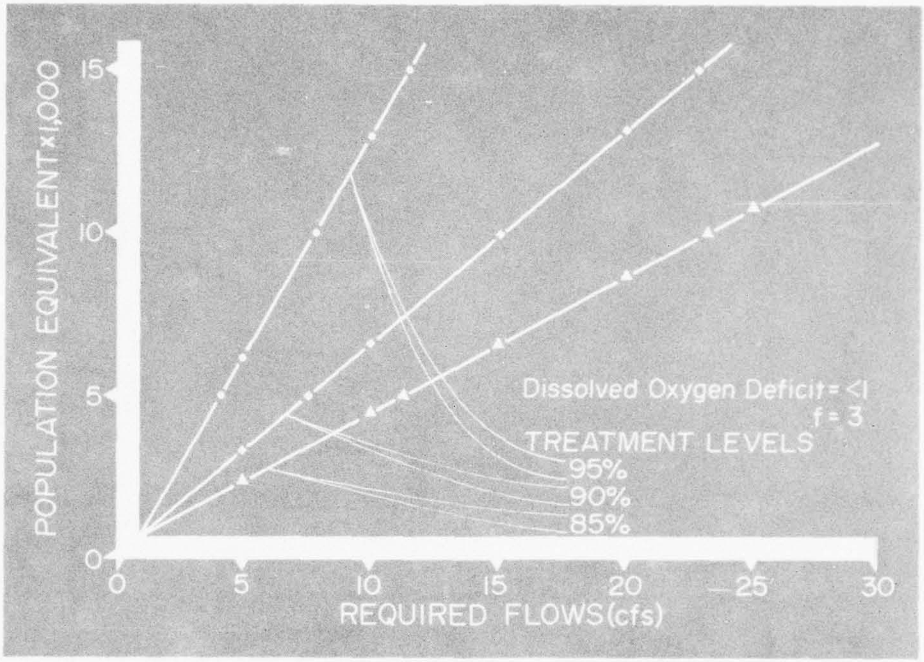
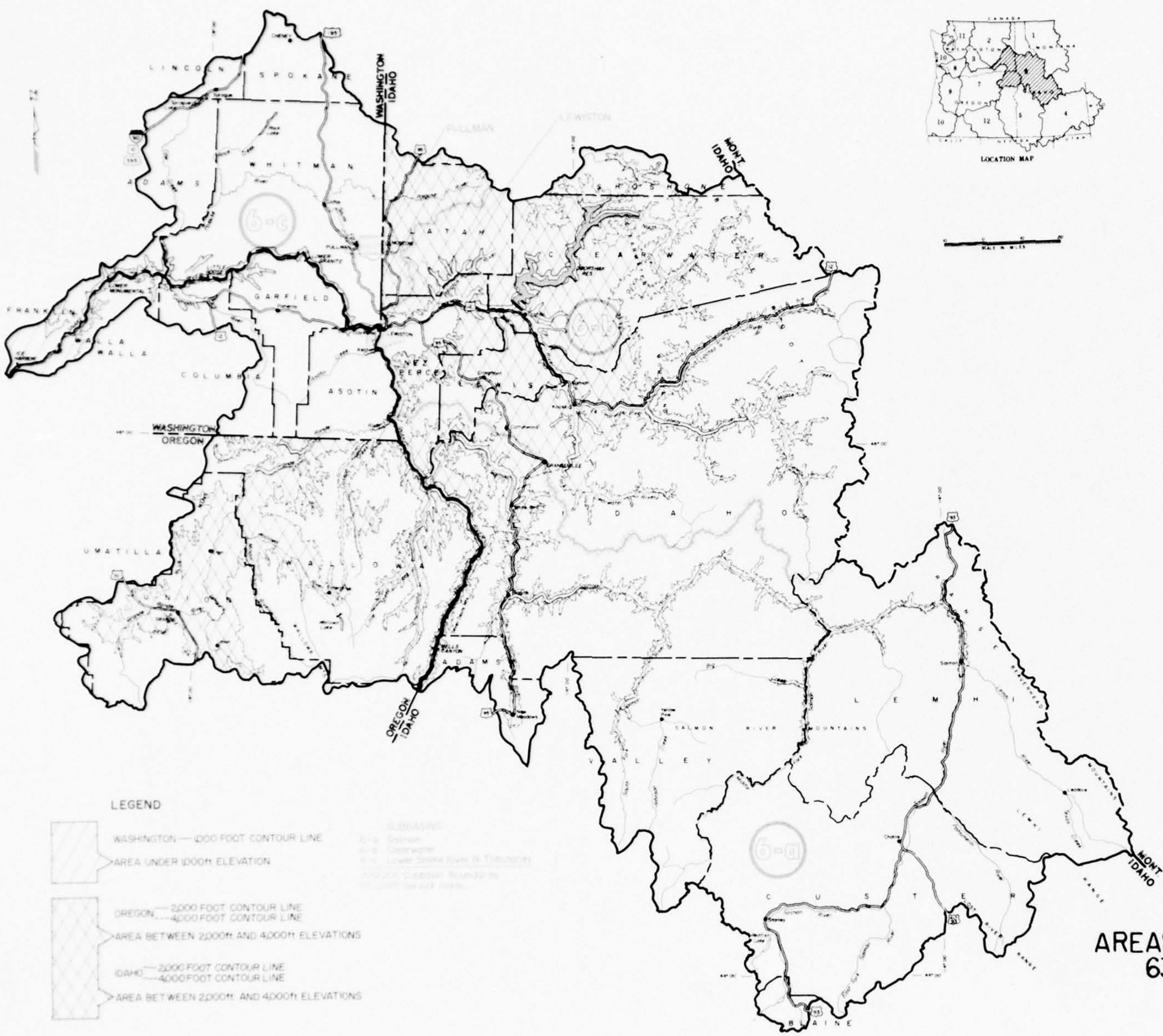


FIGURE 65. Minimum Flow Needs to Maintain Dissolved Oxygen Near Saturation Values

All curves are necessarily based on very broad assumptions and are intended to give an indication of the magnitude of flows versus treatment needed to maintain dissolved oxygen standards only. Other standards criteria will control in many cases and could very likely require that flows two or three times greater than those shown in the figures be provided. For example, in some areas it has been necessary to maintain a 20/1 streamflow/effluent dilution ratio to prevent slimes and other aesthetically displeasing conditions occurring below secondary treated sewage discharges. Based on per capita waste flows expected in 2020, a streamflow of 54 cfs would be needed to provide this dilution to secondary effluent from a community of 10,000 persons. In contrast, a flow of only 25 cfs would be required to meet a dissolved oxygen standard which allows a deficit of 1.0 mg/1.

In addition to the general curves discussed above that apply primarily to discharges from small municipalities to tributary streams, specific flow requirements to meet dissolved oxygen standards criteria have been computed for stream reaches in portions of the Palouse and Grande Ronde drainages.



COLUMBIA-NORTH PACIFIC
COMPREHENSIVE FRAMEWORK STUDY

AREAS TO WHICH FIGURES 63,64 AND 65 APPLY

LOWER SNAKE SUBREGION 6

1969

FIGURE 66

Palouse Basin

Figures 67, 68, and 69 show estimated minimum flow needs to meet dissolved oxygen standards in the Palouse Basin. These flows were developed during a preliminary study of Palouse Basin water quality control needs conducted in December 1967. The flow requirements are based on treatment to remove 85 percent of the biochemical oxygen demand from collectable wastes before discharge, and on maintaining minimum dissolved oxygen concentrations of 6.5 mg/l in receiving waters.

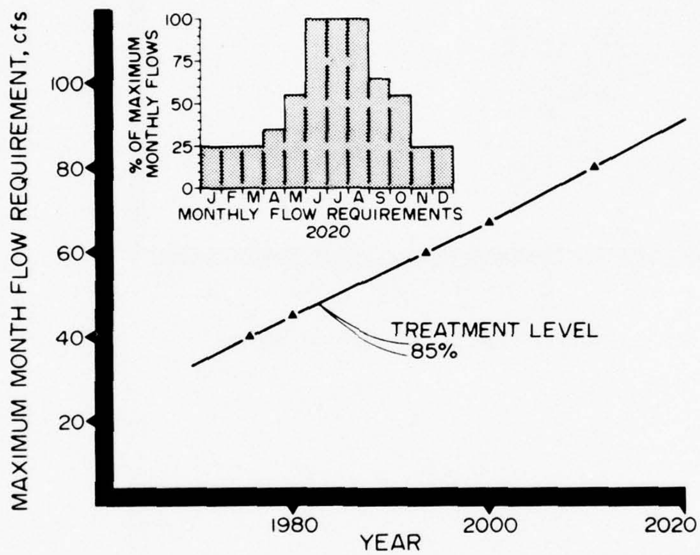


FIGURE 67. Minimum Flow Needs for Water Quality Control, Paradise Creek at Moscow

Note: Average annual flow is 53 percent of maximum month flow.

Grande Ronde Basin Figure 70 shows minimum flow needs in Catherine Creek to meet dissolved oxygen standards criteria in the old Grande Ronde channel below the mouth of Catherine Creek. The flow needs are based on assimilation of projected 2020 municipal waste discharges from the cities of Union and LaGrande. Since the flow needs are based primarily on waste discharges from the LaGrande lagoon, an alternative means of disposal of the lagoon effluent by piping to the Grande Ronde River was considered. Minimum flows required to assimilate these wastes and the industrial wastes discharged at Island City under 2020 conditions are shown in figure 71. The minimum flow needs were determined during recent water quality studies of the basin, (19)

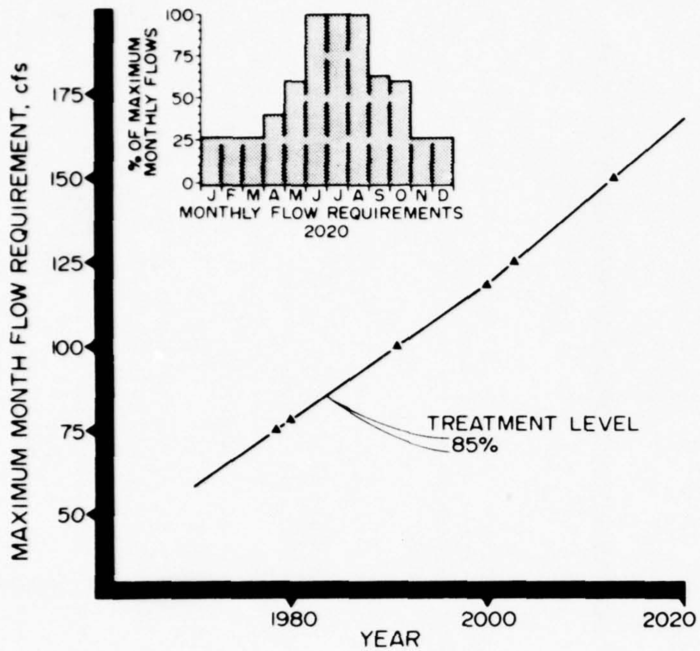


FIGURE 68. Minimum Flow Needs for Water Quality Control, South Fork Palouse at Pullman

Note: Average annual flow is 55 percent of maximum month flow.

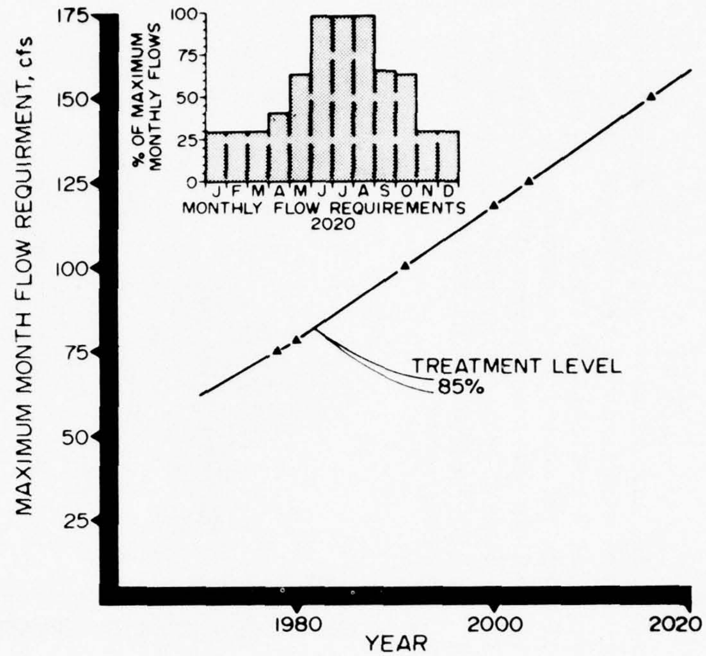


FIGURE 69. Minimum Flow Needs for Water Quality Control, Palouse River at Colfax

Note: Average annual flow is 57 percent of maximum month flow.

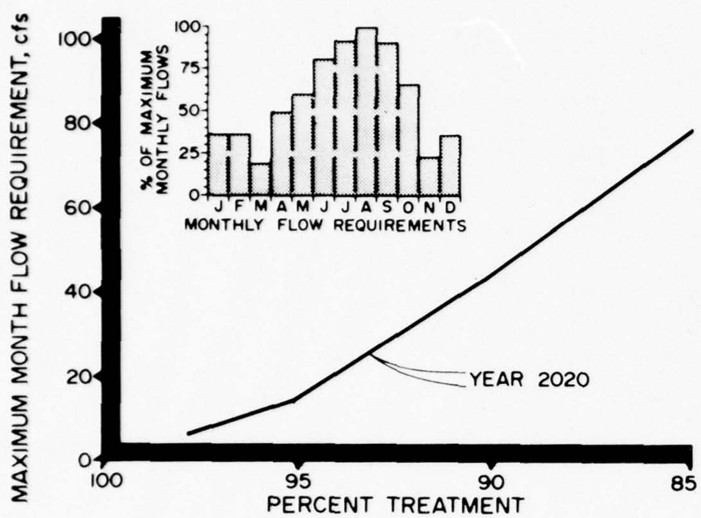


FIGURE 70. Minimum Flow Needs for Water Quality Control, Catherine Creek at *mouth of Ladd Creek* (2020 conditions)

Note: Average annual flow is 62 percent of maximum month flow.

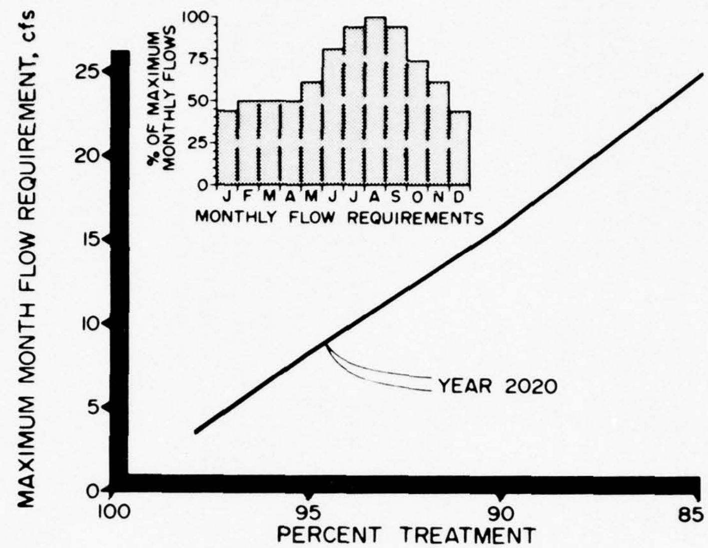


FIGURE 71. Minimum Flow Needs for Water Quality Control, Grande Ronde River *near Island City* (2020 conditions)

Note: Average annual flow is 66 percent of maximum month flow.

which were undertaken in connection with water resource investigations of the area. A major conclusion of the studies was that additional irrigation of the Grande Ronde Valley could cause dissolved oxygen depletions and excess dissolved solids concentrations in Grande Ronde River below Elgin. Dilution water in addition to that shown in the figures would be required to alleviate these conditions.

Management Practices

The management of the water resources of the Lower Snake Subregion is an important factor in preserving water quality of the streams and rivers. Detailed planning and adequate financing are required so as to prevent potential water pollution which would otherwise result from increasing waste loading. Water quality must be considered in the planning and operation of all new reservoirs and in changes made in present operating procedure. Dependable flows must be guaranteed.

LOCATION MAP

SUBREGION 7

S U B R E G I O N 7

M I D C O L U M B I A

INTRODUCTION

The Mid Columbia Subregion includes the area drained by streams flowing into the Columbia between the Snake on the east and Bonneville Dam on the west. The area contains 29,606 square miles in the states of Oregon and Washington. The subregion is surrounded by mountains; the Cascades on the west, the Ochocos on the south, the Blue Mountains on the east, and the Horse Heaven Hills on the north. Elevations range from over 10,000 feet in the Cascade Range to near sea level at Bonneville Dam. There are no extensive areas of flatland, although there are many broad valleys and rolling hills.

The climatic pattern is one of cool-to-cold winters and hot summers, with the major precipitation period from November to April. Yearly and diurnal temperature extremes are common, both during the summer and winter months. Extreme temperatures range from -33°F. to 115°F. (-36°C. to 46°C.). Annual average precipitation generally ranges between 10 and 20 inches, although at some locations along the Cascades on the west, the annual precipitation is over 130 inches. Also, in the Blue Mountains, average annual precipitation is about 40 inches.

Agriculture and food processing are important economic activities. The subregion contains some of the most important orchard areas in Oregon. The pulp and paper, aluminum, textile, and lumber industries are also of particular economic importance.

The population of the Mid Columbia Subregion in 1965 was about 210,300 persons, of whom about 39 percent live in the four major service areas. Smaller communities are numerous throughout much of the subregion. However, areas of low population predominate in the southern section.

The Mid Columbia Subregion is divided into the Walla Walla, Umatilla, John Day, Deschutes, Hood, and Klickitat Subbasins. The major service areas are the Walla Walla, Pendleton, Bend, and The Dalles areas.

PRESENT STATUS

Municipalities and industries are the most important pollution sources in the Mid Columbia Subregion, contributing suspended and settleable organic materials to waterways. A graphical summary

COLUMBIA-NORTH PACIFIC
COMPREHENSIVE FRAMEWORK STUDY

MUNICIPAL AND INDUSTRIAL WASTES BY SUBBASIN

MID COLUMBIA SUBREGION 7

1970

FIGURE 72

of municipal and industrial organic waste production and discharge for each major subbasin is presented in figure 72. The pulp-and-paper and food-processing industries are the largest waste sources. The rural-domestic population, agricultural animals, and land use are also important pollution sources. However, the magnitude and impact of wastes from these sources are not readily identifiable.

Generally, water quality in the subregion is excellent. Problems are confined to local bacterial contamination of streams below municipalities, high temperatures in the Columbia and several tributaries, and low tributary streamflows during the dry seasons.

Stream Characteristics

Other than the Columbia River, the two principal rivers of the Mid-Columbia Subregion are the Deschutes and the John Day. The Deschutes River has a fairly constant discharge because of the Metolius River, a tributary which originates in the Cascades as a giant spring, and because of large springs on the Lower Crooked River. On the other hand, the Crooked River drainage area contains a large desert that contributes intermittently. The John Day River is largely fed by snowmelt from the Ochoco and Blue Mountains. Other major streams are the Walla Walla River in Washington and Oregon, the Umatilla River in Oregon, and the Klickitat and White Salmon Rivers in Washington. The Oregon streams are fed by snowmelt from the Blue Mountains, and the Washington streams drain into the Columbia from the Cascades.

Average annual runoff from the subregion amounts to about 16,200 cfs (11.7 million acre-feet). The mean annual discharge from the Columbia River at Bonneville Dam is 177,400 cfs (128.4 million acre-feet).

Surface-Water Hydrology

The discharge pattern for the subregion is characterized by peak discharges between January and May (a direct result of precipitation and snowmelt) and minimum flows during the fall. Table 94 presents monthly discharge data for selected stations in the subregion.

From the standpoint of waste discharge control, the low-flow months from July to October are the most important. In most of the subregion, August is the critical month. One-in-ten-year

Table 94 - Average Monthly Discharge, Subregion 7(12)

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
						(CFS)							
Walla Walla River near Milton, Ore.	203	236	305	422	416	259	131	109	106	113	153	213	222
Walla Walla River near Touchet, Wn.	776	1,034	1,288	1,287	799	265	36	20	28	116	252	761	555
Umatilla River at Pendleton, Ore.	500	738	1,097	1,416	880	335	73	32	38	68	216	491	489
Willow Creek at Heppner, Ore.	15.06	28.0	43.3	49.7	36.4	16.2	2.5	0.2	0.2	1.8	4.5	11.4	17.4
John Day River at Picture Gorge near Dayville, Ore.	357	558	870	1,293	1,034	563	110	37	49	123	201	323	458
N. Fork John Day River at Monument, Ore.	656	1,178	2,184	3,833	3,561	1,618	350	113	100	146	277	616	1,217
John Day River at Service Creek, Ore.	1,148	1,967	3,420	5,559	4,930	2,360	516	155	148	276	516	1,044	1,831
John Day River at McDonald's Ferry, Ore.	1,306	2,174	3,573	5,605	5,034	2,558	596	170	158	280	521	1,124	1,925
Deschutes River below Lava Island near Bend, Ore.	877	939	1,020	1,170	1,440	1,550	1,710	1,600	1,350	1,090	876	868	1,208
Deschutes River below Bend, Ore.	834	866	898	427	199	207	128	155	208	305	678	802	476
Crooked River near Culver, Ore.	1,470	1,790	2,190	2,670	1,720	1,430	1,270	1,260	1,260	1,320	1,350	1,460	1,599
Deschutes River at Moody near Biggs, Ore.	6,550	6,420	5,600	6,230	5,950	5,370	4,360	4,040	4,090	4,060	4,340	5,220	5,186
Columbia River at The Dalles, Ore.	167,890	203,400	190,200	199,030	244,350	239,167	171,950	127,690	120,000	121,640	127,117	147,490	171,330
Klickitat River near Pitt, Wn.	1,710	2,010	2,100	2,470	2,650	1,960	1,120	782	723	775	945	1,540	1,565
Hood River at Hood River, Ore.	1,400	1,440	1,430	1,500	1,350	1,050	604	397	421	628	1,050	1,600	1,072
White Salmon River near Underwood, Wn.	1,237	1,355	1,424	1,548	2,209	1,345	943	730	647	661	821	1,193	1,176
Columbia River at Bonneville Dam	175,005	211,050	198,025	207,605	252,523	245,300	175,730	130,260	122,355	124,560	131,642	154,675	177,400

low flow is the selected recurrence frequency designated to describe critical low flows. These data are summarized for selected stations in table 95.

Table 95 - One-in-Ten-Year Low Flows, Subregion 7 (12)

Stream and Location	One-in-Ten-Year Low Flow (cfs) 1/
Walla Walla River near Milton, Oregon	70
Walla Walla River near Touchet, Washington	$<$ 10
Umatilla River at Pendleton, Oregon	18
Willow Creek at Heppner, Oregon	$<$ 1
John Day River at Picture Gorge near Dayville, Oregon	$<$ 10
North Fork John Day River at Monument, Oregon	45
John Day River at Service Creek, Oregon	$<$ 10
John Day River at McDonald's Ferry, Oregon	$<$ 50
Deschutes River below Lava Island near Bend, Oregon	590
Deschutes River below Bend, Oregon	30
Crooked River near Culver, Oregon	1,100
Deschutes River at Moody near Biggs, Oregon	3,500
Columbia River at The Dalles, Oregon	106,000
Klickitat River near Pitt, Washington	520
Hood River at Hood River, Oregon	250
White Salmon River near Underwood, Washington	420
Columbia River at Bonneville Dam	102,000

1/ Period of 1 month.

Impoundments and Stream Regulation

Impoundments on the Columbia River provide run-of-the-river power at Bonneville, The Dalles, and McNary Dams; and both power and flood control at John Day Dam. The Deschutes River Basin has two power dams--Pelton and Round Butte--and many irrigation reservoirs, including Crane Prairie and Wickup Reservoirs on the Deschutes River; Prineville Reservoir on Crooked River, and Ochoco Reservoir on Ochoco Creek. There is one dam in the Walla Walla River Basin, which is located on Mill Creek and is operated principally for flood control. The only reservoirs in the Umatilla Basin are McKay and Cold Springs.

The effect of impoundments on water quality in the Mid-Columbia Subregion is not considered to be a major problem. However, diversions for irrigation often have profound effects on the quality of streams. Lower streamflows result in reduced waste assimilative capacities and increased water temperatures, particularly in streams with wide, flat beds.

No storage is authorized for water quality control, although incidental benefits result from releases for other purposes. For instance, operation of McKay Dam and Reservoir has a beneficial influence on water quality in McKay Creek and Umatilla River below Pendleton by augmenting low summer flows and reducing the stream temperature.

Ground-Water Characteristics

Alluvial deposits and the Columbia River basalt are capable of yielding moderately large to large supplies of ground water in Subregion 7. The largest portion of the subregion's population depends on ground-water supplies, particularly in the Umatilla, John Day, Deschutes, and Hood Subbasins.

The water is generally of excellent quality. Total dissolved solids rarely exceed 500 mg/l. The water is usually moderately hard to very hard, and silica frequently is about 40 to 60 mg/l. Troublesome trace elements or constituents are present in several domestic supplies. Bacterial contamination is also a threat to many wells in the Milton-Freewater and Bend areas.

A more detailed discussion of ground water in Subregion 7 is presented in Appendix V, Water Resources.

Pollution Sources

The municipal and industrial waste production and discharges (in population equivalents), and the treatment facilities for the Mid-Columbia Subregion are summarized by subbasin in table 96.

At present, municipalities and industries in the subregion produce organic wastes equivalent to those from a population of 1.41 million persons. Of this total, 58 percent is generated by the food-processing industry, 21 percent by the lumber and wood products industry, and 10 percent by the pulp and paper industry. The remaining 11 percent is produced by municipalities.

Waste treatment and other means of waste reduction decrease the total organic load to the subregion's waters by about 73 percent, so that only about 379,665 PE actually reach waterways. Of this total, 35,465 PE are released by municipalities, and 344,200 PE are discharged by industries.

Table 96 - Summary of Municipal and Industrial Waste Treatment, Subregion 7[1/]

	Municipal					Industrial			
	Secondary	Primary	Lagoons	Others	Total	Food Processing	Pulp & Paper	Lumber & Wood	Total
Walla Walla Subbasin									
Number of facilities	6	0	0	0	6	10	1	0	11
Population served	39,800	0	0		39,800				
PE produced	52,600	0	0		52,600	711,500	135,000	0	846,500
PE discharged	7,080	0	0		7,080	116,000	135,000	0	251,000
% removal efficiency	87	--	--		87	84	0	--	71
Umatilla Subbasin									
Number of facilities	6	2	2	0	10	2	0	3	5
Population served	24,450	840	1,980		27,270				
PE produced	48,150	920	2,000		51,070	37,600	0	134,000	171,600
PE discharged	5,110	515	240		5,865	100	0	0	100
% removal efficiency	89	44	88		88	100	--	100	100
John Day Subbasin									
Number of facilities	4	1	0	3	8	3	0	1	4
Population served	4,110	940	0	800	5,850				
PE produced	4,110	940	0	800	5,850	510	0	0	510
PE discharged	730	470	0	0	1,200	100	0	0	100
% removal efficiency	82	50	--	100	79	80	--	--	80
Deschutes Subbasin									
Number of facilities	0	0	2	4	6	3	0	4	7
Population served	0	0	4,100	14,100	18,200				
PE produced	0	0	4,700	17,100	21,800	18,320	0	820	19,140
PE discharged	0	0	710	350	1,060	0	0	0	0
% removal efficiency	--	--	85	98	95	100	--	100	100
Hood Subbasin									
Number of facilities	0	2	1	0	3	3	0	2	5
Population served	0	13,500	500	0	14,000				
PE produced	0	24,000	500	0	24,500	53,000	0	157,000	210,000
PE discharged	0	15,900	100	0	16,000	53,000	0	40,000	93,000
% removal efficiency	--	34	80	--	35	0	--	75	56
Klickitat Subbasin									
Number of facilities	1	3	0	2	6				
Population served	2,600	2,780	0	1,650	7,030				
PE produced	3,000	2,780	0	1,650	7,430				
PE discharged	450	2,160	0	1,650	4,260				
% removal efficiency	85	22	--	0	43				
Total									
Number of facilities	17	8	5	9	39	21	1	10	32
Population served	70,960	18,060	6,580	16,550	112,150				
PE produced	107,860	28,640	7,200	19,550	163,250	820,930	135,000	291,820	1,247,750
PE discharged	13,370	19,045	1,050	2,000	35,465	169,200	135,000	40,000	344,200
% removal efficiency	88	34	85	90	78	79	0	86	72

1/ FWPCA Inventory of Municipal and Industrial Wastes, Lower Columbia Subregion, 1965.

Other sources of pollution in the subregion include wastes from the rural-domestic population, irrigation, land use, agricultural animals, recreation, and natural sources.

Municipalities

Walla Walla Subbasin The population in the Walla Walla Subbasin served by municipal waste treatment facilities is about 39,800, or 68.7 percent of the subbasin's total population. At present, all communities in the subbasin with sewer systems provide secondary treatment of their waste waters. These plants have an overall removal efficiency of about 87 percent.

The City of Walla Walla has experienced difficulties in recent years as a result of treating food-processing wastes in the municipal facility. During the period of peak demands (June-July), removal efficiencies drop below 70 percent; and about 116,000 PE are discharged to Mill Creek. Some of the plant effluent is diverted to land for irrigation.

All other communities in the subbasin have adequate treatment of wastes. The City of Milton-Freewater pipes sewage effluent from its secondary treatment plant to an irrigation line carrying effluent from three local canneries. The combined load is applied to land for irrigation purposes.

Although the communities of Waitsburg and Dayton provide adequate treatment, low dissolved oxygen levels do occur during summer low-flow periods in the Touchet River.

Umatilla Subbasin Approximately 27,270 persons, or 67.0 percent of the subbasin's population, are served by municipal waste treatment facilities. In general, municipal waste treatment removes about 88 percent of organic oxygen demanding wastes. Also, nearly all plants provide disinfection of effluents.

Sanitary sewage and industrial wastes generated within the Pendleton Service Area are presently treated in a secondary treatment plant in need of expansion. During the period from June to August, food-processing wastes add an organic loading of about 44,000 PE to the facility. As a result, the effluent discharged to the Umatilla River increases from an average of 4,000 PE to over 14,000 PE during the period of low streamflow.

The community of Heppner has an adequate secondary treatment plant. However, it discharges waste effluents to Willow Creek which has low summer flow.

Other municipalities in the subbasin have adequate treatment facilities. Only the communities of Umatilla and McNary, providing primary treatment, and Boardman and Pilot Rock, with lagoons, have less than secondary treatment.

John Day Subbasin Municipal treatment facilities serve about 5,850 persons, or 37.5 percent of the subbasin's population. In general, these facilities provide satisfactory treatment of their wastes. An overall removal efficiency of 79 percent of the oxygen-demanding load is accomplished. The average organic loading to the subbasin waterways by municipal sources is only 1,200 PE.

Of the communities with municipal treatment facilities, only Arlington, Moro, and Long Creek do not provide secondary treatment.

Bates and Canyon City discharge 180 and 280 PE, respectively, after treatment by individual septic tanks. The remainder of the communities rely upon individual septic tanks discharging to subsurface drain fields. The Oregon State Sanitary Authority reports that sewer systems and treatment plants are needed at Bates, Canyon City, Ukiah, Mt. Vernon, Dayville, Izee, Mitchell, and Kinzua.

Deschutes Subbasin Only about 39.7 percent of the subbasin population, or 18,200 persons, are served by municipal waste treatment facilities in the Deschutes Subbasin. The municipalities utilize effective treatment and disposal practices, allowing only 1,060 PE to enter the subbasin waterways. Removal of about 95 percent of the wastes generated is accomplished. In addition, all waste effluents are disinfected before discharge to streams.

In the Bend Service Area, about eight percent of the population are served by municipal sewer systems. The wastes that are collected do not receive any form of treatment before disposal to lava sinkholes. The majority of the population depend on septic tanks and individual subsurface disposal to sinkholes or seepage pits. No pollution of streams or ground water as a result of this kind of disposal has been detected. However, close surveillance of the ground-water quality in the area should be maintained.

Prineville and Warm Springs have lagoons, and the remainder of the municipal systems use septic tanks and Imhoff tanks. The communities of Culver, Madras, Metolius, Redmond, and Sisters have no sewage collection systems but rely on individual subsurface disposal of wastes.

Hood Subbasin About 14,000 persons, or 43.5 percent of the Hood Subbasin population, are provided with municipal waste treatment facilities. Primary treatment plants at The Dalles and Hood River serve 10,000 and 3,500 persons, respectively; and an oxidation lagoon at Dufur serves 500 persons. These facilities discharge a total organic oxygen-demanding load of about 16,000 PE, representing an overall efficiency of about 35 percent. The remaining municipalities in the subbasin generally depend on individual septic tanks and drain fields for disposal of wastes.

Under the Oregon Water Quality Standards Implementation Plan, the cities of The Dalles and Hood River are to provide secondary treatment by July 1972.

Pollution from municipal sources is approaching a critical stage in a few reported areas. The community of Parkdale has no public sewer system, and problems have occurred as a result of the disposal of septic tank effluent. Tile drainages discharge into open drainage ditches that flow into Trout Creek. Although gross pollution of the river does not occur, a local bacterial problem is evident. Another problem area is below the community of Odell, which also has septic tanks but which is now constructing a secondary treatment plant.

Klickitat Subbasin Only 38.8 percent of the subbasin population, or about 7,030 persons in the Klickitat Subbasin, are served by municipal facilities. The municipal systems have an overall removal efficiency of only 43 percent and discharge 4,260 PE to the subbasin's waters. Even though most treatment facilities are in need of upgrading, no critical pollution problems exist.

Treatment facilities within the subbasin include a secondary treatment plant at Goldendale; primary treatment plants at White Salmon, Bingen, and Klickitat; and a septic tank at Wishram. Stevenson is the only community in the Mid-Columbia Subregion now discharging wastes to the Columbia River without any form of treatment. The Washington Water Quality Standards call for secondary treatment, disinfection, and outfall facilities at Stevenson by 1972.

Industries

Walla Walla Subbasin Industrial wastes in the Walla Walla Subbasin are mostly from the food-processing and pulp-and-paper industries. The pulp-and-paper industry discharges about 135,000 PE to the Columbia River without any waste treatment. During the summer months, the food-processing industry achieves a removal efficiency of 84 percent of the oxygen-demanding load, with a resulting waste release of about 116,000 PE.

The food-processing industries are located in Walla Walla, Milton-Freewater, Weston, Dayton, and Waitsburg. Average monthly raw waste production during the pea-processing season (mid-June through July) has averaged about 700,000 PE per day in recent years, although daily peaks have approached 1,000,000 PE. Except at Walla Walla, essentially all of these wastes are used for spray irrigation or discharged to non-overflow lagoons. A separate industrial sewer and secondary treatment plant serve food processors at Walla Walla. Some of the industrial wastes are treated in the municipal plant. An effluent with an organic loading of about 116,000 PE is discharged to Mill Creek or to irrigation

systems. It is estimated that about 90 percent of the oxygen-demanding wastes applied to the land are removed. The return flow represents an estimated additional waste load of 30,000 PE to the subbasin's waters.

A 560-ton-per-day kraft pulp mill is operated at Wallula. The plant has excellent in-plant control processes. However, no treatment facilities are provided except small lagoons for emergency waste storage. An average annual waste load of 135,000 PE is discharged to the Columbia River. The Washington Water Quality Standards require secondary treatment of the mill's wastes by December 1971.

Other industrial pollution sources in the subbasin are limited to a number of small sawmill and lumber operations. Although no data are available as to the relative extent of the problems it is not believed to be significant.

Umatilla Subbasin The major industrial waste producers in the Umatilla Subbasin are the food-processing and lumber-manufacturing industries. Treatment practices are good, generally allowing the discharge of only small waste loads. However, summer pea-canning and freezing operations result in significant waste discharges to the subbasin's waterways during low flow periods.

In the Pendleton area, most industries utilize the municipal waste treatment plant. An industrial waste load of about 10,000 PE is discharged to the Umatilla River during the summer months from the municipal facilities.

Most other industries practice land disposal of their wastes. The lumber-manufacturing industry at Pilot Rock operates two storage lagoons from October to March. During the remainder of the year, the wastes are applied to land for crop irrigation. The food-processing industry at Athena disposes of its wastes by crop irrigation. A total waste load of about 167,000 PE is applied to land for crop irrigation. Assuming a 95 percent reduction in oxygen-demanding wastes by the land, this results in an organic load of about 8,000 PE to the subbasin's waters.

Other waste sources in the subbasin are limited to small sawmill and lumber operations. However, their waste contribution is probably insignificant.

John Day Subbasin Industrial wastes are not a serious problem in the John Day Subbasin. However, a sawmill at Bates discharges log pond wastes to the Middle Fork of the John Day River which have caused pollution problems downstream. The only other industries are small meatpacking and slaughterhouse

operations and local creameries. Present treatment, consisting mainly of septic tanks and drainage fields, is considered adequate for the most part.

Deschutes Subbasin Industrial sources of pollution in the Deschutes Subbasin include dairies, food-processing plants, and the lumber-manufacturing industry. In general, no industrial wastes are discharged to the subbasin's waters. Land application or disposal to lava sinkholes is usually practiced.

A lumber company at Bend handles logs in the Deschutes River, and this practice results in debris problems.

Hood Subbasin Major industries in the Hood Subbasin include food processing, lumber manufacturing, and aluminum processing. The subbasin's industries have an overall waste reduction efficiency of 56 percent and discharge about 93,000 PE to the watercourse.

A milling and hardboard plant at Dee discharges 40,000 PE of wood product wastes to the Hood River. The sawmill operates ponds and disposes of wastes to land, but the hardboard plant provides only a flow-through lagoon. The wood sugar, pulp, and bark wastes have encouraged excessive algal growth, depressed the dissolved oxygen level, decreased the aesthetic appearance of the river, and caused problems in irrigation diversion facilities.

There are several food-processing industries in The Dalles and Hood River discharging wastes directly to the Columbia River. During the summer season, a waste load of about 53,000 PE is released without treatment. There are several companies packing fresh fruit in the Hood River area that discharge washing water, after screening, directly to the Hood River or irrigation drains leading to the river. The extent of pollution from this practice is unknown.

Very little data are available regarding discharge to the Columbia River from an aluminum company at The Dalles. It may be high in fluorides, inorganic solids, and oils and may be of a higher temperature than the river. Depending on the method of handling pot liners, cyanide may also be a problem.

Klickitat Subbasin Industrial sources of pollution in the Klickitat Subbasin are limited to small sawmill and lumber operations. Although no data are available concerning waste discharges, they are not believed to be significant.

Rural-Domestic

A summary of population and percentage of the population served by individual waste disposal systems in each subbasin and for the subregion as a whole is presented in table 97. With the exception of the Walla Walla and Umatilla Subbasins, the majority of the population are classed as rural-domestic.

In general, the pollution problem from rural-domestic wastes is confined to local contamination of ground water. This is of particular concern in several locations, including the Milton-Freewater area; parts of the John Day Subbasin; the middle Deschutes area; and the vicinity of The Dalles and Hood River. The problem is usually associated with individual sewage disposal systems, consisting of septic tanks and subsurface drain fields. In most cases, contamination is most serious in shallow domestic well supplies, but in the Milton-Freewater and middle Deschutes areas contamination of deep ground-water tables is also of concern. Water quality surveys have been conducted in the middle Deschutes area, where drain holes have been drilled through as much as several hundred feet of lava rock for the disposal of septic tank effluent. The studies indicate that it is only a matter of time before uncontrolled discharge of wastes will cause ground-water pollution. Here, as in most places, once the ground-water becomes polluted, it may remain unusable for a long period of time.

Table 97 - Summary of Population Served by Individual Waste Disposal Facilities, Subregion 7 1/

Subbasin	Population Served Thousands	Percent Subregion Population	Percent Subbasin Population
Walla Walla	18.1	8.6	31.3
Umatilla	13.4	6.4	33.0
John Day	9.7	4.6	62.5
Deschutes	27.6	13.1	60.3
Hood	18.2	8.7	56.5
Klickitat	11.1	5.3	61.2
	98.1	46.7	

1/ Derived as a residual from FPCA Municipal and Industrial Waste Inventory, Mid-Columbia Subregion, 1965.

Irrigation

Approximately 542,000 acres are presently irrigated in the Mid-Columbia Subregion. This irrigation requires an annual diversion of 2.4 million acre-feet of water. About 0.9 million acre-feet return to streams as irrigation return flow. Ridge and furrow methods of irrigation are practiced on about 75 percent of the irrigated land, and the remaining land is generally irrigated by sprinkler methods.

Irrigation return flows have considerable detrimental effect on water quality in several areas--including the Touchet River in the Dayton-Waitsburg area, the Walla Walla River and Mill Creek in the Walla Walla area, the Umatilla River in the Pendleton area, Willow Creek in the Heppner area, and the John Day River. The major problems have been a result of added nutrient and BOD loadings to the streams, as well as suspended materials. Heavy algal blooms and aesthetic nuisance conditions have often resulted.

Also of importance is the diversion of water for irrigation during periods of low and sometimes normal streamflow. This reduces the waste assimilation capacity of the stream and makes it undesirable for recreation and fisheries use. Poor water quality conditions may thus occur below many otherwise adequate secondary treatment plants as a result of the lack of water to assimilate residual wastes.

Agricultural Animals

Domestic stock and wild range animals in the Mid-Columbia Subregion constitute a significant source of BOD, nutrients, and bacterial pollution. The estimated organic waste potential of the animal population is equivalent to that from a population of 3.9 million people. An estimated 95 percent of the wastes generated are reduced through soil filtration and natural decomposition, so that about 200,000 PE eventually reach waterways.

The largest concentrations of animals are along the John Day, Deschutes, and Umatilla Rivers. The impact of their wastes on water quality is greatest in the Umatilla and John Day Subbasins since streams in these areas are subject to extreme low flow conditions. The occurrence in relatively unpopulated areas of stream BOD concentrations ranging upwards of 3.5 to 4.0 mg/l and coliform counts as high as 7,000 organisms per 100 ml is probably the result of animal wastes.

Other Land Uses

The production and transport of sediment are the most significant quality impairments resulting from land use in the Mid-Columbia Subregion. The generalized sediment yields range between 0.02 and 4.0 acre-feet per square mile per year. Studies of available data show that the largest sediment source is sheet erosion on upland agricultural land. Studies of soil loss in the northwestern states indicate that the agricultural belt in the Walla Walla watershed has the highest erosion rates; the agricultural area of the northern counties in Oregon, more moderate rates; and the mountainous range and forested land, progressively lower rates.

Present Water Quality

A relatively small amount of data has been collected for most reaches of the Mid Columbia since quality monitoring agencies have budgetary limitations, and the Columbia River lies between two states. However, the state agencies have an ambitious water quality monitoring program for intrastate streams, and both Washington and Oregon have now begun regular sampling programs on the Columbia.

There are many conflicts among analyses from different agencies at comparable stations along the river. This is especially evident with respect to iron, phosphate, and nitrogen analyses and may be due to sampling or analytical techniques. In the future, efforts should be made to resolve such differences. For the present, inferences must be made from the existing data.

The Columbia's discharge ranks it as the fourth largest river in North America and provides ample dilution capacity to absorb impacts from its somewhat sparsely developed basin with few significant changes in water quality characteristics.

The waters of the Mid-Columbia are generally good from the standpoint of dissolved oxygen, color, turbidity, hardness, dissolved solids, biochemical oxygen demand, and radioactivity. Problems do occur in the main stem and tributaries with respect to temperature, nutrient levels, and bacterial and biological contamination. Recently, concern has been raised about supersaturation of nitrogen as a significant problem affecting fisheries.

Main Stem Columbia River

The dissolved oxygen in all reaches of the Columbia River from McNary Dam to Bonneville Dam averages well above saturation,

as shown in figure 73. The dissolved oxygen levels average about 9 mg/l at all stations on the main stem, and the minimum levels are above 6.5 mg/l. Figure 74 shows a mean Columbia River dissolved oxygen profile.

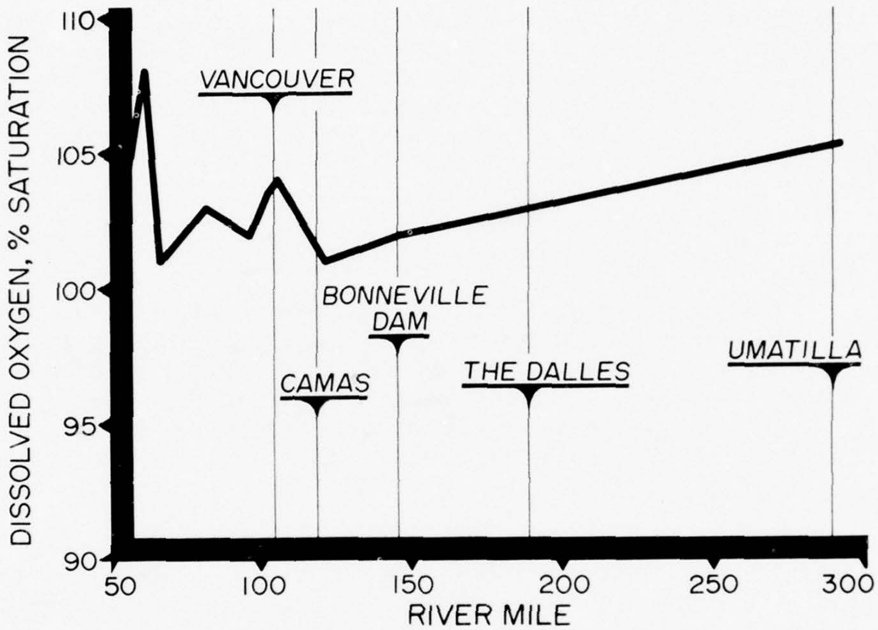


FIGURE 73. Dissolved Oxygen, Percent Saturation, Columbia River.

The Oregon State Water Quality Standards provide that no wastes shall be discharged into the Columbia River which cause dissolved oxygen levels to fall below 90 percent of saturation. This condition is generally satisfied throughout the length of the Mid-Columbia. One OSSA survey, on September 11 and 12, 1967, showed afternoon values of 86, 89, and 87 percent saturations for river miles 292.0, 290.5, and 268.1, respectively. Six other stations in the same survey showed saturations greater than 90 percent. The saturations below 90 percent cannot be attributed to other than natural causes, and no detrimentally low DO levels occurred.

The BOD data for the Mid-Columbia River generally show low BOD levels. A FWPCA Water Surveillance Station at Bonneville Dam shows an average BOD of 1.1 mg/l at river mile 145.5. This low value, coupled with the generally satisfactory dissolved oxygen level, indicates that BOD levels are not of problem porportions.

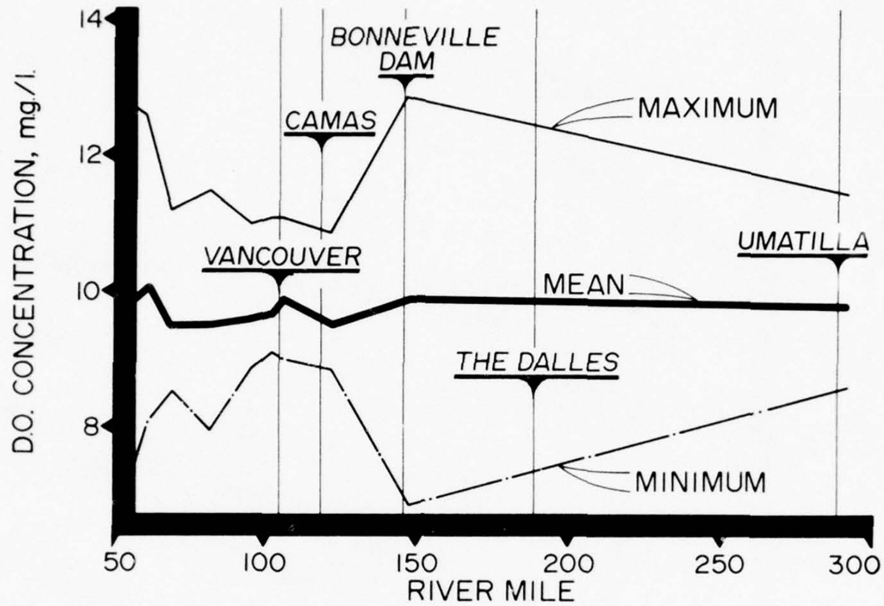


FIGURE 74. Dissolved Oxygen Profile, Columbia River.

Coliform data for relatively few stations on the Mid-Columbia River are available. Figure 75 shows a mean coliform profile of the river. Oregon and Washington State Water Quality Standards require that median coliform counts shall not exceed 240/100 ml throughout the portion of the main stem in the Mid Columbia Subregion. Available data show that the standards are met in this reach of the river.

Maintaining adequate temperature levels is one of the most significant problems complicating water resource management of the Columbia River today and might grow in importance as thermal power plants are built. Elevated temperatures have detrimental effects on salmonid fisheries which make up a significant portion of the economic resources of the Columbia Basin. For protection of anadromous fish migration, Oregon and Washington temperature standards for the Columbia River permit no measurable increases in river temperature from unnatural waste sources or activities when such river temperatures are 68°F. (20°C.) or above. Figure 76 presents a temperature profile of the Lower Columbia River for the critical months of July, August, and September. Figure 77 shows the mean monthly variation in water temperatures at three stations along the river. By examining figures 76 and 77, it is apparent that summer water temperatures in the Columbia River exceed the State standards from McNary Dam to Bonneville Dam.

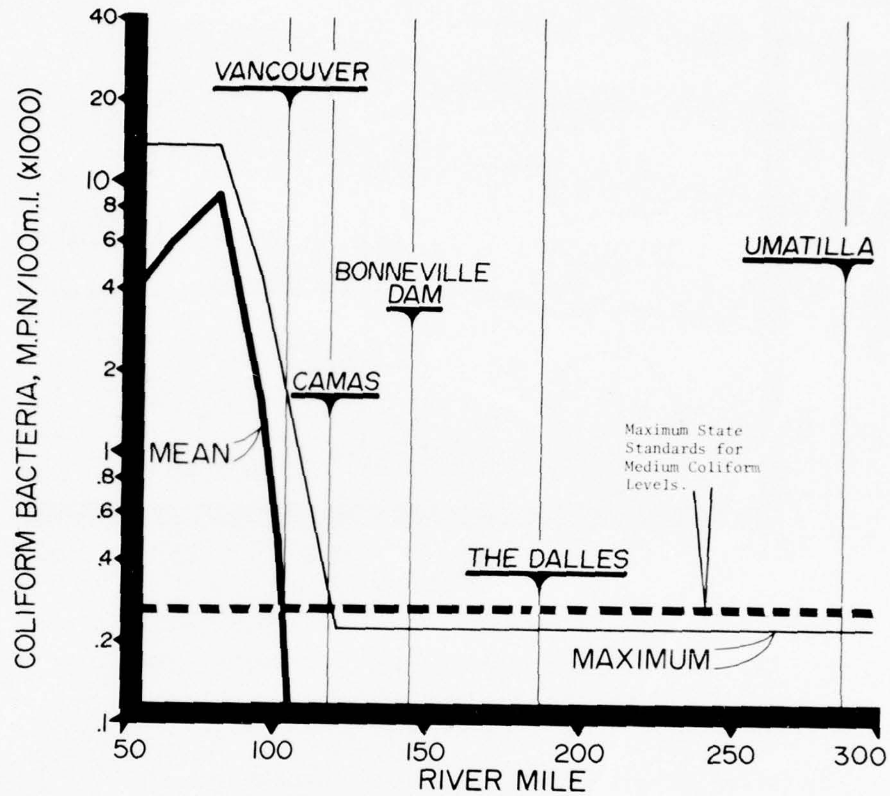


FIGURE 75. Coliform Bacteria Profile, Columbia River.

Figure 78 shows nutrient and trace element levels for the Columbia River. In the Mid-Columbia the concentrations of nutrients (orthophosphates and nitrates) and trace elements are above limiting values for stimulation of algal blooms. However, no nuisance aquatic growths have been reported.

The potential for abnormally high, and perhaps even harmful, levels of radioactivity in the Columbia River exists primarily as a consequence of discharges of the Hanford Atomic Works upstream from Richland, Washington. Levels of activity to date have not approached the danger level, and continuous monitoring by AEC and Battelle Northwest and also by the states of Washington and Oregon and FWQA will provide adequate warning if a hazard develops. Gross beta activity at McNary Dam has averaged only 273 picocuries/liter as compared with the PHS raw water supply standard of 1,000 picocuries/liter.

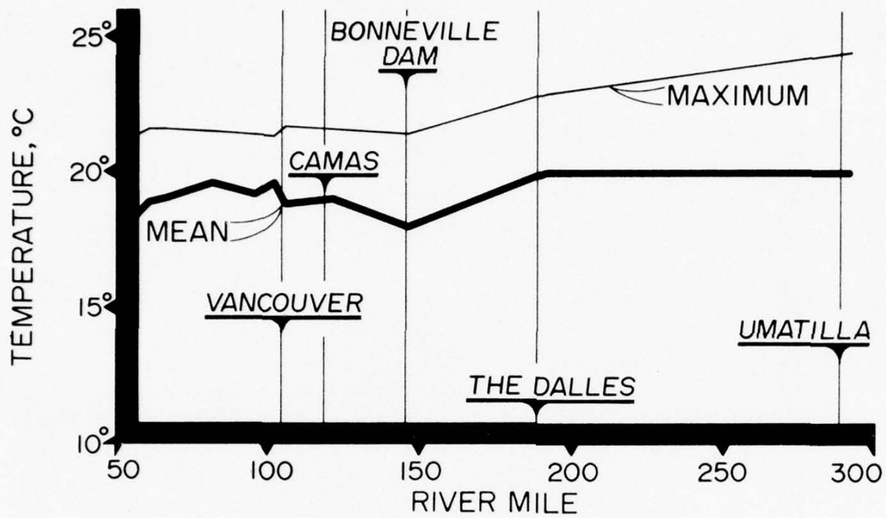


FIGURE 76. Temperature Profile, Columbia River.

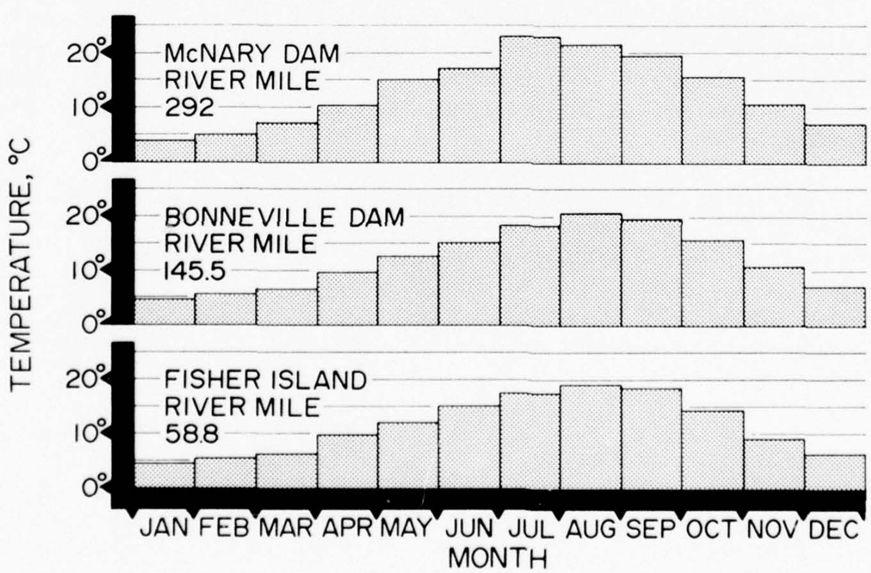


FIGURE 77. Mean Monthly Temperatures, Columbia River.

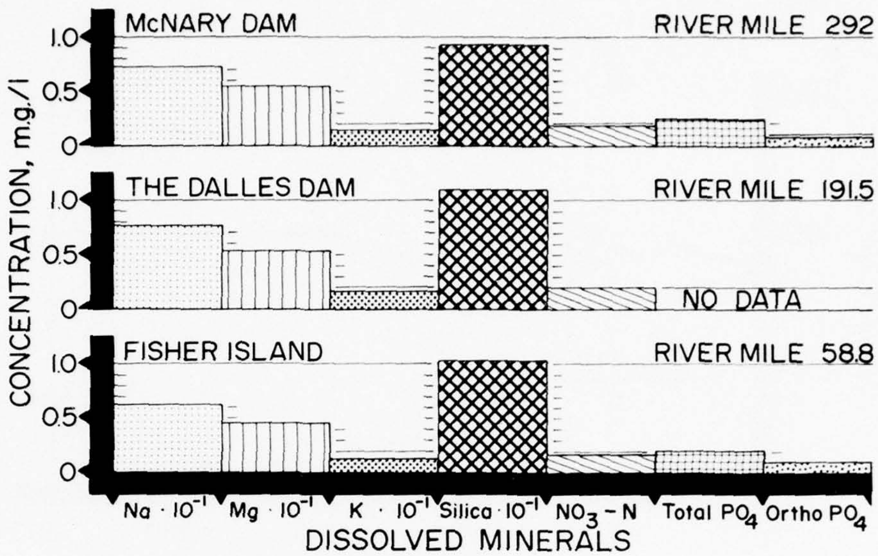


FIGURE 78. Dissolved Minerals Concentration, Columbia River.

Supersaturated levels of dissolved nitrogen as high as 140 percent have recently been reported by the Bureau of Commercial Fisheries. The condition persists all along the Columbia River from Grand Coulee Dam to the mouth and presents a threat to migratory salmonids.

Although there is a considerable difference in the chemical quality of the tributaries of the Columbia River in this subregion, the overall variation in the quality of the main stem is slight. The average flow of the individual tributary streams is less than 3 percent of the average flow of the Columbia River, and they would have to carry extremely high solute loads to affect its mineral quality.

The Columbia River at McNary Dam contains a calcium magnesium bicarbonate water with an average dissolved solids concentration of 109 mg/l. Downstream at The Dalles Dam below all major tributaries which enter this subregion, the average dissolved solids concentration is 114 mg/l. A study of the chemical quality record at The Dalles Dam since 1950 reveals no short-term trend of mineral quality change that cannot be attributed to variation in discharge. (14)

Tributaries

The major tributaries in the Mid Columbia Subregion are the Walla Walla, Umatilla, John Day, Deschutes, Hood, and Klickitat Rivers. Table 98 presents a summary of physical, chemical, and bacteriological parameters important to water quality control for selected stations.

The Walla Walla, Umatilla, John Day, and Deschutes Rivers reflect the arid climate and the use of water for irrigation. In the upper reaches, these streams are usually low in dissolved solids and contain relatively clear waters. With the exception of summer low-flow conditions, the streams flow to the Columbia without serious water quality degradation. Quality problems during much of the year are restricted to excessive turbidity during periods of high runoff. However, during the summer, as the streams flow through the arid parts of the subregion, stream diversions and irrigation return flows significantly affect water quality. In the Walla Walla, Umatilla, and John Day Subbasins, stream diversions have resulted in flows too low to assimilate oxygen-demanding wastes and in some cases have reduced a stream to stagnant pools where biological nuisance conditions occur. Irrigation return flows contribute to increases in suspended and dissolved solids, color, turbidity, and temperatures. Nutrient concentrations have reached levels significantly above the threshold limit for algal stimulation (0.3 mg/l for nitrates and 0.025 mg/l for phosphates). Phosphate concentrations have been reported at over 1.0 mg/l in the Walla Walla and Umatilla Rivers, and over 0.4 mg/l in the John Day and Deschutes Rivers. Log pond overflow from a sawmill at Bates causes slime pollution in the Middle Fork of the John Day River. Stream temperatures have frequently averaged over 70°F. (21°C.) on a monthly basis and have on occasion risen to maximum daily temperatures above 80°F. (27°C.). Such conditions have often resulted in nuisance aquatic growths.

Irrigation use of the Klickitat, White Salmon, and Hood Rivers is less extensive. Also, the streams flow through less arid plateau area than the other rivers in the subregion. Consequently, they are still relatively low in dissolved solids when they enter the Columbia River. These streams become very turbid during high runoff and snowmelt periods since they are largely derived from glacial areas.

Municipal waste effluents result in bacterial contamination below many population centers, including Walla Walla, Dayton, Pendleton, Heppner, and towns in the upper reaches of the John Day River. Local bacterial contamination resulting from septic tank drainage also occurs on the John Day and Hood Rivers. However, high counts have been found on occasion in unpopulated areas,

Table 98 - Summary of Water Quality Data for Tributaries, Subregion 7[1/]

	River Mile	D.O. (mg/1)	T (°C)	Coliform MPN/100ml	pH	Color PT-CO Units	Hard. (mg/1)	Turb. (JTU)	TDS (mg/1)	Ortho PO_4 (mg/1)	NO_3-N (mg/1)
Walla Walla River	313.5-13.0										
Mean		10.6	13.3	5,524	7.6	8	110	59	207	0.38	0.46
Min.		8.2	1.8	230	7.0	5	30	5	78	0.21	0.11
Max.		14.5	25.0	46,000	8.5	35	318	300	569	0.80	1.04
Touchet River	313.5-16.4-53.2										
Mean		11.1	8.4	72,280	7.5	10.4	29	-	76	0.10	0.07
Min.		9.1	0.0	0	7.0	5.0	21	-	66	0.00	0.02
Max.		12.7	20.5	460,000	8.3	25.0	34	-	86	0.23	0.16
Umatilla River	288.8-57.1										
Mean		10.3	10.7	266	7.9	9	32	6	100	0.15	0.06
Min.		7.9	4.0	13	7.2	3	20	1	77	0.03	0.01
Max.		13.2	28.0	2,400	9.0	22	39	16	133	0.44	0.15
Umatilla River	288.8-48.0										
Mean		10.8	12.4	21,520	7.9	22	41	7	133	0.55	0.30
Min.		8.2	2.5	450	7.0	7	25	4	101	0.18	0.02
Max.		13.7	23.0	70,000	8.4	50	53	12	209	1.16	0.55
Umatilla River	288.8-2.2										
Mean		11.7	14.0	1,886	8.2	9	129	5	270	0.28	0.57
Min.		9.3	4.0	45	7.1	0	31	0	119	0.01	0.02
Max.		16.0	25.0	7,000	8.9	25	232	48	1,110	0.60	1.32
John Day River	218-247.1										
Mean		9.7	11.2	5,335	8.1	14	113	10	225	0.46	0.20
Min.		3.3	4.0	230	7.4	4	87	1	153	0.16	0.01
Max.		13.1	22.5	70,000	8.8	28	150	45	392	0.85	0.56
John Day River	218-21.0										
Mean		10.9	12.3	422	8.1	10		19	247	0.10	0.08
Min.		7.2	1.0	21	7.5	1		0	119	0.01	0.01
Max.		14.4	25.0	7,000	8.9	27		80	1,200	1.12	0.38

Table 98 (Continued)

	River Mile	D.O. (mg/1)	T (^oC)	Coliform MPN/100ml	pH	Color (PT-CO) Units	Hard. (mg/1)	Turb. (JTU)	TDS (mg/1)	Ortho PO_4 (mg/1)	NO_3-N (mg/1)
Deschutes River	204.1-168.8										
Mean		10.0	10.4	115	7.5	5	21	5	88	0.16	0.04
Min.		8.1	3.0	5	7.1	0	4	0	51	0.04	0.01
Max.		12.3	18.0	500	8.0	15	30	18	158	0.54	0.19
Deschutes River	204.1-133.4										
Mean		10.7	12.3	133	7.9	7	27	4	84	0.11	0.07
Min.		7.1	0.5	4	6.9	0	1	0	9	0.00	0.01
Max.		13.3	25.0	620	9.5	14	47	11	244	0.24	0.21
Crooked River	204.1-113.8-3.3										
Mean		10.2	12.1	165	8.0	4	56	5	147	0.19	0.12
Min.		9.0	2.0	23	7.4	0	3	0	61	0.00	0.01
Max.		12.0	19.5	700	9.4	10	74	20	253	0.91	0.42
Metolius River	204.1-111.3-10.7										
Mean		11.0	10.5	111	7.6	4	34	5	107	0.14	0.05
Min.		8.9	5.0	6	7.2	0	2	0	62	0.01	0.01
Max.		12.7	25.0	700	9.2	13	62	14	170	0.64	0.19
Deschutes River	204.1 - 96.8										
Mean		11.2	11.3	345	7.9	6	41	5	112	0.18	0.09
Min.		9.2	2.0	23	7.3	0	3	0	9	0.07	0.01
Max.		13.5	17.0	2400	9.9	11	50	16	164	0.60	0.22
Deschutes River	204.1-1.0										
Mean		11.2	11.6	345	8.1	6	41	5	112	0.18	0.09
Min.		9.2	5.0	23	7.6	0	3	0	9	0.07	0.01
Max.		12.7	19.0	2400	8.4	11	50	16	164	0.60	0.22
White Salmon River	168.3-2.0										
Mean		-	-	-	7.4	5	22	1	60	0.09	0.05
Min.		-	-	-	7.0	0	17	0	43	0.04	0.00
Max.		-	-	-	7.7	15	25	5	75	0.21	0.18

1/ FWPCA STORET, 1968.

indicating that soil bacteria and animal populations can have a decided effect on the level of coliform bacteria.

Dissolved oxygen levels for most streams in the subregion are normally satisfactory and present no water quality problems, except in two areas. In the Walla Walla Subbasin, seasonal discharges of inadequately treated industrial wastes, coupled with low flows resulting from irrigation diversions, cause depletion of dissolved oxygen to near septic conditions in Mill Creek and the lower Walla Walla River. In the Hood Subbasin, dissolved oxygen blocks have occurred during the summer months in the East Fork of the Hood River below the plywood mill on that river.

The maximum observed suspended-sediment concentration in the subregion has been 316,000 mg/l in a small stream in the Walla Walla Subbasin. The highest concentrations observed generally occurred during the great flood of December 1964; however, sediment concentration is high during any flood period. In December of 1964, some of the small streams in the north-central Oregon area had peak concentrations of 125,000 mg/l or higher and had sufficient water discharge to transport exceptionally large amounts of sediment. The John Day River, which had a maximum observed concentration of 100,000 mg/l during the December 1964 flood, transported 9.2 million tons of suspended sediment during the period from December 21 to 31. This was more than eight times the amount discharged during the entire 1963 water year.

Summary of Problems

A graphical summary of water quality problem areas in the Mid Columbia Subregion is presented in figure 79. With the exception of the main stem Columbia River, most problems are associated with low streamflows.

Inadequately treated municipal wastes result in bacterial contamination of surface waters in the Walla Walla, Umatilla, John Day, and Hood Rivers. In addition, septic tank drainage and agricultural animal wastes are sources of coliform bacteria. Municipal and rural-domestic wastes also threaten to contaminate ground water in the Milton-Freewater and Bend areas.

The discharge of large quantities of industrial wastes during low summertime flows causes dissolved oxygen depressions in the Hood and Walla Walla Rivers and Mill Creek.

Excessive algal blooms and aquatic growths occur in the Walla Walla, Umatilla, John Day, Middle Fork John Day, and Hood Rivers and in Mill and Willow Creeks. Municipal and industrial

wastes, irrigation return flows, and agricultural animal wastes, in combination with low summer streamflow, are generally responsible for the condition.

The summer temperature levels of the Columbia River are above recommended limits for fish migration. While high water temperatures in the Columbia River are primarily from natural causes, the Hanford Atomic Works discharges large quantities of waste heat.

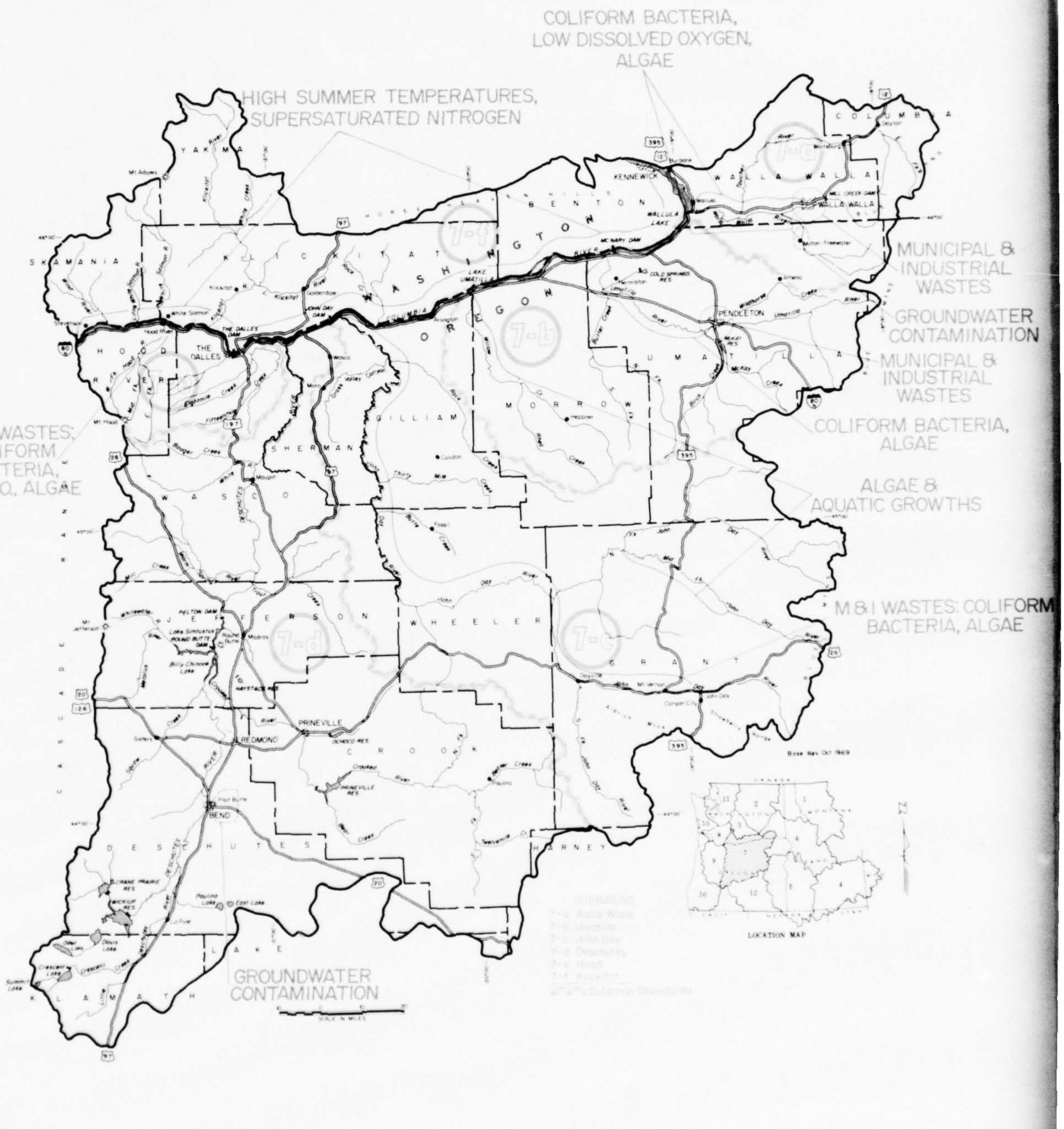
The Columbia River contains supersaturated values of dissolved nitrogen gas, which causes gas-bubble disease in fish. The supersaturation phenomenon--especially its persistence throughout the Mid Columbia--is not well understood as yet; however, as discussed in the regional summary, a study is underway to determine its cause, effect, and to recommend possible solutions.

FUTURE WATER QUALITY MANAGEMENT NEEDS

Based on the projected economic development of the Mid Columbia Subregion, the population is expected to increase from 210,300 in 1965 to 404,400 in 2020. This is an increase of 90 percent for the subregion, compared with 121 percent for the region.

Figure 80 shows the projected subbasin populations for the years 1980, 2000, and 2020. The projected subbasin and service area populations for municipal and rural categories are presented in table 99. Nearly half of the population will be centered in the Walla Walla, Pendleton, Bend, and The Dalles Service Areas by 2020.

Industrial development in the future will continue to be based on the subregion's abundant forests and productive food crops. Production by the pulp and paper mills and the lumber and wood products industries is expected to increase by one and one-half times by 2020. The food products industry is expected to increase production by two and one-half times during the same period.



COLUMBIA–NORTH PACIFIC
COMPREHENSIVE FRAMEWORK STUDY

MAJOR WATER QUALITY PROBLEM AREAS

MID COLUMBIA SUBREGION 7

1970

FIGURE 79

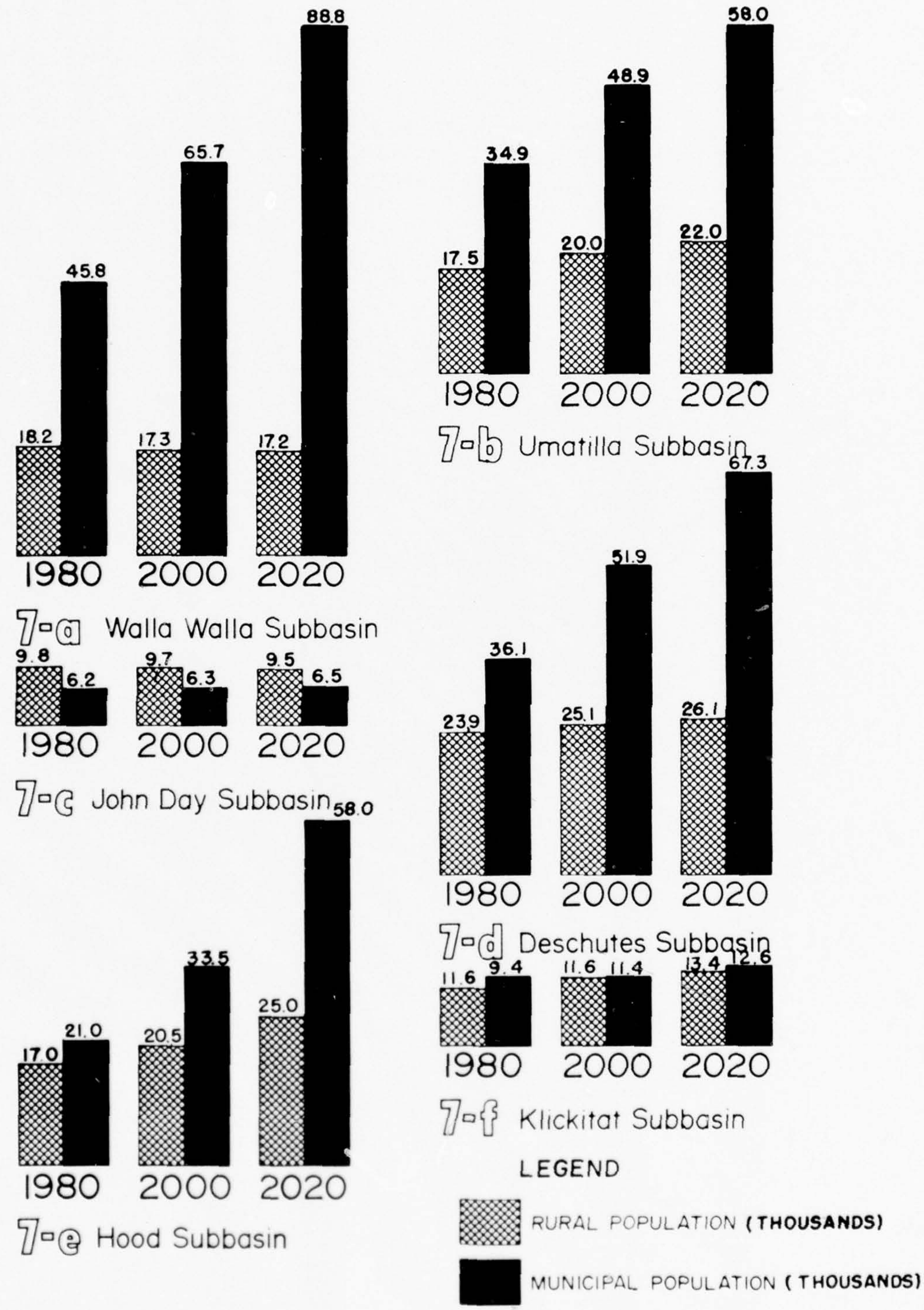


FIGURE 80. Projected Population, Subregion 7

Table 99 - Projected Population, Subregion 7 1/

	1980	2000	2020
		Thousands	
Walla Walla Subbasin	64.0	83.0	106.0
Walla Walla Service Area	39.5	56.6	73.9
Municipal	38.0	55.9	73.9
Rural	1.5	0.7	--
Other	24.5	26.4	32.1
Municipal	7.8	9.8	14.9
Rural	16.7	16.6	17.2
Subtotal	64.0	83.0	106.0
Municipal	45.8	65.7	88.8
Rural	18.2	17.3	17.2
Umatilla Subbasin	52.4	68.9	80.0
Pendleton Service Area	23.1	27.7	31.3
Municipal	23.1	27.7	31.3
Rural	--	--	--
Other	29.3	41.2	48.7
Municipal	11.8	21.2	26.7
Rural	17.5	20.0	22.0
Subtotal	52.4	68.9	80.0
Municipal	34.9	48.9	58.0
Rural	17.5	20.0	22.0
John Day Subbasin	16.0	16.0	16.0
Municipal	6.2	6.3	6.5
Rural	9.8	9.7	9.5
Deschutes Subbasin	60.0	77.0	93.4
Bend Service Area	18.1	24.5	31.3
Municipal	16.1	23.5	31.3
Rural	2.0	1.0	--
Other	41.9	52.5	62.1
Municipal	20.0	28.4	36.0
Rural	21.9	24.1	26.1
Subtotal	60.0	77.0	93.4
Municipal	36.1	51.9	67.3
Rural	23.9	25.1	26.1
Hood Subbasin	38.0	54.0	83.0
The Dalles Service Area	15.2	20.9	28.7
Municipal	12.4	19.5	28.7
Rural	2.8	1.4	--
Other	22.8	33.1	54.3
Municipal	7.6	14.0	29.3
Rural	15.2	19.1	25.0
Subtotal	38.0	54.0	83.0
Municipal	21.0	33.5	58.0
Rural	17.0	20.5	25.0
Klickitat Subbasin	21.0	23.0	26.0
Municipal	9.4	11.4	12.6
Rural	11.6	11.6	13.4
TOTAL SUBREGION	251.4	321.9	404.4
Municipal	152.4	218.6	291.2
Rural	99.0	103.3	113.2

1/ Derived from Economic Base and Projections, Appendix VII, Columbia-North Pacific Framework Study, January, 1971 and from North Pacific Division Corps of Engineers data. Differences between totals in this table and source are due to differences in subregion boundaries. The source is based on economic boundaries and this table is based on hydrologic boundaries. The municipal population is defined as that population discharging wastes to a municipal sewerage system. The rural population is defined as the residual.

Future Waste Production

Municipal

The projected municipal raw waste production for the Mid Columbia Subregion is presented in table 100. The population served by municipal waste collection and treatment systems is expected to be increased from 54 percent in 1967 to 72 percent by the year 2020. The entire population in the four major service areas is expected to be served by municipal systems by that time.

Table 100 - Present and Projected Municipal Raw Organic Waste Production 1/, Subregion 7

	1970 2/	1980	2000	2020
		(1,000's P.E.)		
Walla Walla Subbasin	52.2	57.3	82.1	111.0
Walla Walla Service Area	42.2	47.5	69.9	92.4
Other	10.0	9.8	12.2	18.6
Umatilla Subbasin	34.2	43.7	61.1	72.5
Pendleton Service Area	22.6	28.9	34.6	39.1
Other	11.6	14.8	26.5	33.4
John Day Subbasin	7.5	7.8	7.9	8.1
Deschutes Subbasin	35.1	45.6	64.9	84.1
Bend Service Area	17.5	20.1	29.4	39.1
Other	17.6	25.5	35.5	45.0
Hood Subbasin	20.0	25.0	41.9	72.5
The Dalles Service Area	13.5	15.5	24.4	35.9
Other	6.5	9.5	17.5	36.6
Klickitat Subbasin	8.6	11.8	14.3	15.8
Total Subregion	157.6	191.2	272.2	364.0

1/ A factor of 1.25 was applied to the municipal population components to account for the effects of small commercial establishments and other urban activities which add to municipal waste loads.
2/ Interpolated from 1965 data and 1980 projections.

The municipal waste loading outside of the four major service areas is expected to increase at a faster rate than in the service areas. The municipal waste loading in the service area will be 57 percent of the subregion's total as compared with

61 percent at the present time. The Walla Walla Service Area will be the largest municipal waste producer in the subregion.

Industrial

Projected raw organic waste loadings for the major industrial categories are presented in table 101 for the years 1980, 2000, and 2020. By the end of the projection period, it is expected that industries will contribute approximately 90 percent of the subregion's total organic waste loading. The food products industry will continue to be the major organic waste source, contributing approximately 75 percent of the industrial waste production. The pulp and paper, and wood products industries are other major industrial organic waste producers. The primary metals industry may be a major source of fluorides, inorganic solids, oils, and heat--particularly in The Dalles Service Area.

Table 101 - Projected Industrial Raw Organic Waste Production, Subregion 7 1/ (5) (17)

	1970	1980	2000	2020
		(1,000's P.E.)		
Pulp and Paper	204.8	344.5	444.7	494.4
Lumber and Wood Products	300.3	317.2	337.6	357.9
Food Products	1,003.6	1,369.0	1,890.0	2,620.0
Total	1,508.7	2,030.7	2,672.3	3,472.3

1/ Base data from FWPCA Inventory of Municipal and Industrial waste, Mid Columbia Subregion, 1965.

In general, increases in waste production will occur at existing operations for most industries. However, a new pulp and paper mill is expected in the Oregon portion of the subregion. The Bend-Redmond and Hood River areas are the most likely sites.

Rural-Domestic

The projected rural-domestic waste production is summarized in table 102 for the years 1980, 2000, and 2020. The rural-domestic waste production was assumed to be equal to the rural population component shown in table 99. For most areas outside of the four major service areas the rural waste production is expected to remain relatively constant or to increase slightly.

Table 102 - Projected Rural Domestic Raw Organic Waste Production, Subregion 7

	1970 1/	1980	2000	2020
		(1,000's P.E.)		
Walla Walla Subbasin	15.2	18.2	17.3	17.2
Umatilla Subbasin	17.4	17.5	20.0	22.0
John Day Subbasin	9.7	9.8	9.7	9.5
Deschutes Subbasin	26.4	23.9	25.1	26.1
Hood Subbasin	17.8	17.0	20.5	25.0
Klickitat Subbasin	11.3	12.6	11.6	13.4
Total Subregion	97.8	99.0	104.2	113.2

1/ Interpolated from 1965 data and 1980 projections.

Irrigation

In 1966, there were approximately 542,000 acres of land irrigated, which required an annual diversion rate of 4.4 acre-feet per acre. Irrigated acreage is projected to increase to 860,000 acres by 1980; 950,000 acres by 2000; and 1,220,000 acres by 2020.

Other Land Uses

Projections of land use in the subregion, by major types of land, are shown in table 103. The projections show a decrease in land area for forest, whereas the wood consumption demand by the forest products industry is expected to increase. The potential for erosion and stream damage will be greater as more intensive harvesting methods are employed by forest users.

Increased use of fertilizers and pesticides on crop and pasturelands will represent a potential source of nutrients and toxic material which could cause serious water quality problems. The agricultural belt in the Walla Walla watershed is noted for the highest erosion rates, loading the streams with sediments.

Table 103 - Present & Projected Land Use, Subregion 7, (5), (8)

	1966	1980	2000	2020
		(thousands of acres)		
Land Use				
Cropland	3,571	3,729	3,735	3,805
Irrigated	(525)	(834)	(918)	(1,186)
Nonirrigated	(3,046)	(2,895)	(2,817)	(2,619)
Forest	8,328	8,274	8,206	8,118
Range 1/	6,358	6,176	6,162	6,106
Other 2/	565	613	675	733
Total	18,822	18,792	18,778	18,762

1/ Does not include forest range.
2/ Includes barren land, roads, railroads, small water areas, urban and industrial areas, farmsteads, airports, etc.

Agricultural Animals

The raw organic waste production by the livestock population in the subregion is expected to be equivalent to that from a population of 5,700,000 in 1980; 7,600,000 in 2000; and 10,000,000 in 2020. This would account for approximately 72 percent of the total raw organic waste production for the subregion. It is projected that most of the cattle will be on feedlots by 2020, causing more of the animal waste to be concentrated.

Recreation

The projected raw waste production by recreational activities in the subregion is summarized as follows:

Year	Population Equivalents 1/
1970	76,000
1980	115,500
2000	213,000
2020	392,000

1/ Bureau of Outdoor Recreation and U.S.D.A. Forest Service Projections for total man recreation days (TMRD).

In the determination of wastes from recreation activities, the population equivalent is based on the total annual recreation days. The values represent the daily raw waste production for a typical summer weekend. In a number of lakes, wastes associated with recreational activities may be the largest source of organic materials, nutrients, and bacteria.

Other Factors Influencing Quality

Mining and mineral processing are a source of sediments and toxic materials. Little increase in mining activity and mineral processing is expected as long as prices of domestic minerals remain the same. An increase in prices will reactivate the mining activity.

The construction of reservoirs creates pools from free-flowing streams in which the physical and chemical properties and the biological populations are modified. Withdrawals from different levels result in various temperatures and dissolved oxygen concentrations influencing water quality downstream.

Water Quality Goals

The water quality goals represent the levels of water quality required to fully support the maximum water uses. In managing the subregion's water, the primary purpose is to protect and enhance the quality and value of the water resources; to establish programs for the prevention, control, and abatement of water pollution; and to allow maximum use of the resource for all beneficial purposes.

Water quality standards were adopted by the states of Oregon and Washington after holding public hearings, and the Secretary of Interior has approved the standards, thereby making them Federal standards as well. The states have also developed water quality standards for intrastate waters which are consistent with the interstate standards. These water quality standards are the basis for the water quality goals in this study.

In establishing the water quality standards, the use of each body of water was determined, and criteria were set to protect these uses through quality levels which must be maintained. In addition, the standards incorporate an anti-degradation provision by requiring the waters whose existing quality is better than the established standards be maintained at the existing higher quality level. Also, the standards require that the highest and best practicable treatment under existing technology be applied to all waste discharges. The common parameters generally used are dissolved oxygen concentrations, temperature, turbidity, and coliform density.

The water quality standards are summarized in table 104. The criteria are not inclusive, and the water quality standards should be consulted for specific information. Copies of the

water quality standards are available upon request from the Oregon Department of Environmental Quality and the Washington Water Pollution Control Commission.

Table 104 - Water Classification and Criteria
Subregion 7 (Washington)

Water Quality Parameters	Class AA Extraordinary	Class A Excellent	Class B Good
Coliform	50 MPN	240 MPN	1,000 MPN
Dissolved oxygen	9.5 mg/l	8.0 mg/l	6.5 mg/l
Temperature 1/	60°F.	65°F.	70°F.
pH	6.5-8.5	6.5-8.5	6.5-8.5
Turbidity	5 JTU	5 JTU	10 JTU
Aesthetic values	- Shall not be impaired by the presence of materials or their effects, excluding those of natural origin, which offend the sense of sight, smell, touch, or taste.		

1/ For all classes, the permissible increase in temperature over natural conditions is less than 1.8°F.

Water Quality Criteria, Subregion 7 (Oregon)

Coliform	240/100 ml
Dissolved oxygen	90% low flow and 95% during spawning
Temperature	2°F. increase below 56°F.
pH	7.0 to 8.5
Turbidity	10% increase when natural turbidity is over 30 JTU; below 30 JTU, no increase.

MEANS TO SATISFY DEMANDS

Controlling pollution in the Mid Columbia Subregion in order to provide water quality sufficient to adequately serve the river system's functions will require a coordinated program of waste reduction, flow regulation, application of waste-controlling techniques, and development of a system of cooperative management of the watershed for pollution control.

Waste Treatment

Future Waste Discharge

Future water quality management in the subregion is largely dependent on providing adequate municipal and industrial waste treatment. Based on treatment levels described in the Regional Summary and on raw waste projections presented earlier, the projected municipal waste loadings to be discharged to the waters of each subbasin are presented in table 105.

Table 105 - Projected Municipal Organic Waste Discharges, Subregion 7

	1980	2000	2020
		(1,000's P.E.)	
Walla Walla Subbasin	8.6	8.2	11.1
Walla Walla Service Area	7.1	7.0	9.2
Other	1.5	1.2	1.9
Umatilla Subbasin	6.5	6.1	7.2
Pendleton Service Area	4.3	3.5	3.9
Other	2.2	2.6	3.3
John Day Subbasin	1.2	0.8	0.8
Deschutes Subbasin	6.8	6.5	8.4
Bend Service Area	3.0	3.0	3.9
Other	3.8	3.5	4.5
Hood Subbasin	3.7	4.2	7.3
The Dalles Service Area	2.3	2.4	3.6
Other	1.4	1.8	3.7
Klickitat Subbasin	1.8	1.4	1.6
TOTAL SUBREGION	28.6	27.2	36.4

The waste discharges for major industrial categories are shown in table 106. The total municipal and industrial organic waste loadings to the receiving waters are expected to be 333,200 PE in 1980, 294,500 PE in 2000, and 383,600 PE in 2020.

Table 106 - Projected Industrial Organic Waste Discharges, Subregion 7

	1980	2000	2020
		(1,000's P.E.)	
Industrial Category			
Pulp and Paper	51.7	44.5	49.4
Lumber and Wood Products	47.6	33.8	35.8
Food Products	205.3	189.0	262.0
TOTAL	304.6	267.3	347.2

Treatment Costs

Curves showing estimated costs of construction (total capital) and operation (annual operation and maintenance) of municipal sewage treatment plants for various treatment levels are presented in the "Means to Satisfy Demands" section of the Regional Summary.

Other Pollution Control Practices

Rural wastes will be of major significance in several locations. The individual sewage disposal systems, consisting of septic tanks and subsurface discharges, will continue to represent a possible hazard to ground water in the Milton-Freewater area, parts of the John Day area, the middle Deschutes area, and in the vicinity of The Dalles and Hood River. In most cases, the shallow domestic well supplies are in danger; but, in the middle Deschutes area, drain holes have been drilled through several hundred feet of lava rock for disposal of septic tank effluent. Water quality surveys have been conducted and indicate that it is only a matter of time before the wastes will cause ground-water pollution. Once the ground water is polluted, it may remain unusable for a long time. The use of these waste-water wells must be discontinued immediately.

Controls to minimize land runoff of sediments are essential for maintenance of water quality in the Mid Columbia Subregion. Land management practices by agricultural interests in the Walla Walla watershed must reflect the need for protection against soil erosion.

The large animal population in the subregion represents a source of organic wastes larger than all other waste sources. The largest concentrations are along the banks of the John Day,

Deschutes, and Umatilla Rivers. Fences and simple retaining structures between the animal habitat and watercourses should be provided in order to prevent bank erosion and to limit surface drainage so that the wastes may decompose through soil processes. In most cases, it may be preferable to collect the wastes for treatment or for spreading on the land as a fertilizer.

Minimum Flow Requirements

Since waste treatment does not provide an economic solution for complete removal of contaminants, and since treatment of the waste discharges from non-point sources is not practical, a certain amount of streamflow is necessary for dilution and assimilation of residual wastes. The minimum flow requirements for assimilation of wastes are related to a number of factors, including the strength and deoxygenation capacity of the wastes; and the temperature, reaeration capacity, elevation, and minimum allowable dissolved oxygen for the stream.

A set of generalized curves showing minimum flow requirements for raw waste loadings subjected to various treatment levels is presented in figure 81 for several D.O. objectives, elevations, and selfpurification factors (a combined characteristic of the waste and stream). Figure 82 shows generalized areas to which particular figures are applicable. These figures give only approximate requirements for small to middle-sized communities with a normal mix of municipal and industrial wastes.

Walla Walla Service Area

The population of the Walla Walla Service Area is projected to increase steadily from 33,900 in 1965 to 73,900 in 2020. The food-processing industry will represent the major waste source, with an estimated maximum monthly raw waste production of 380,000 PE in 1980; 570,000 in 2000; and 835,000 in 2020.

Figure 83 presents the minimum streamflow requirements for the projection period. Although approximately one-half of the treated effluent is discharged to the irrigation canals at the present time, it is assumed that 85 percent of the total load will reach the Walla Walla River.

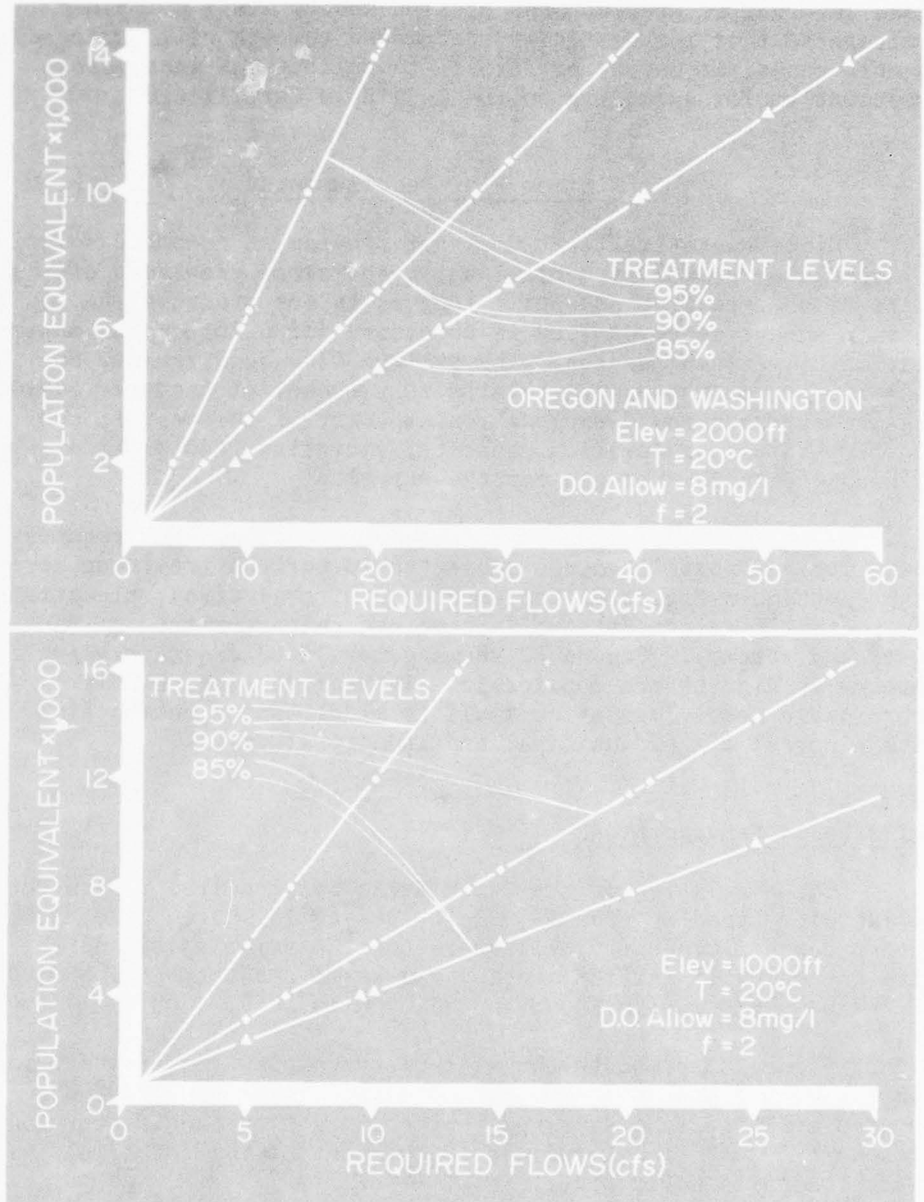


FIGURE 81. Minimum Flow Needs to Maintain Oregon and Washington Dissolved Oxygen Standards Criteria

COLUMBIA–NORTH PACIFIC
COMPREHENSIVE FRAMEWORK STUDY

AREAS TO WHICH FIGURE 81 APPLIES

MID COLUMBIA SUBREGION 7

1970

FIGURE 82

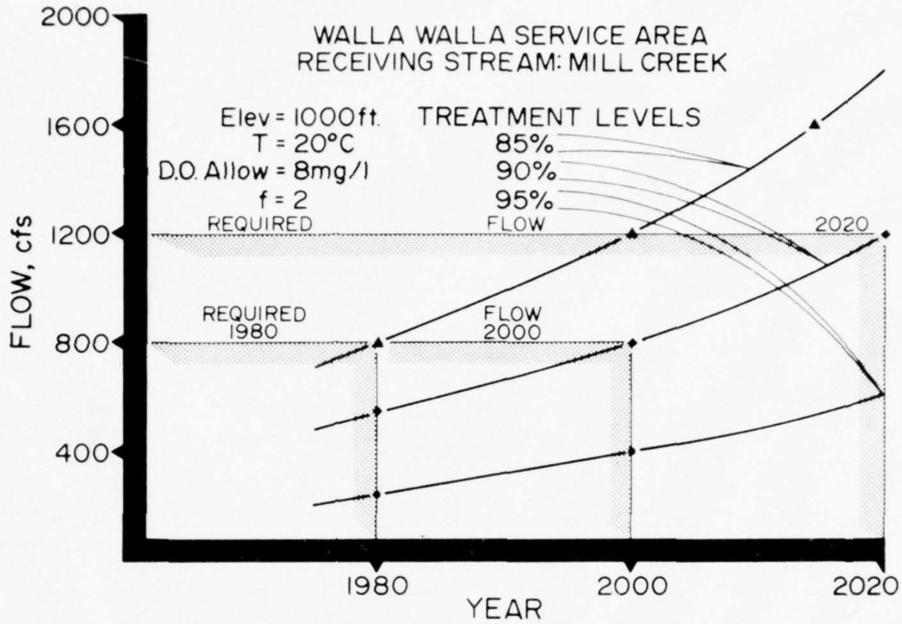


FIGURE 83. Minimum Flow Needs for Water Quality Control, Mill Creek at Walla Walla

Pendleton Service Area

The population of the Pendleton Service Area is expected to increase from 15,600 in 1965 to 31,300 in 2020. The food-processing industry is expected to represent the major organic waste source; and, combined with the municipal waste, the maximum monthly waste production is estimated to be 92,900 PE in 1980; 122,800 PE in 2000 and 160,000 PE in 2020.

Figure 84 presents the minimum streamflow requirements for the projection period.

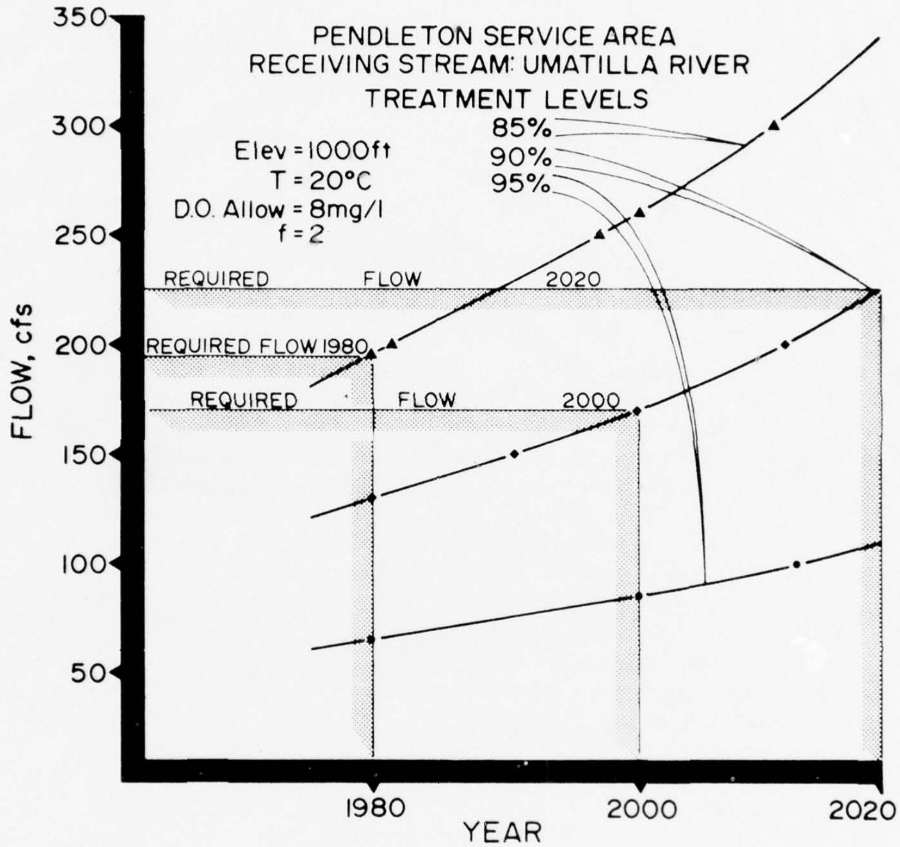


FIGURE 84. Minimum Flow Needs for Water Quality Control, Umatilla River at Pendleton

Bend Service Area

The population of the Bend Service Area is projected to increase from 16,400 in 1965 to 31,300 in 2020. At the present time, the wastes are discharged to lava sinkholes without treatment, and no pollution of streams or ground water has been detected to date. Close surveillance of the ground-water quality should be maintained.

The Dalles Service Area

The population of The Dalles Service Area is projected to increase from 14,200 in 1965 to 28,700 in 2020.

Other Minimum Flow Requirements

Minimum flow requirements may be required because of the pulp and paper industries' expanding and developing new sites. The Bend-Redmond area is considered to be a possible site for a new mill by 1980, and the Hood River area is considered as an alternate location.

Management Practices

The management of the water resources of the Mid Columbia Subregion is an important factor in preserving water quality of the streams. While flows are generally adequate to assimilate waste that enters the streams, both now and in the future, dependable flows must be guaranteed. A number of dams are being planned that could have a significant effect on the flow regimen of major streams. The diversion of water for irrigation--especially during periods of low flow--reduces the waste-assimilation capacity of a stream and makes it undesirable for recreation and fishery uses. Irrigation return flows may have considerable influence on water quality because of the added nutrients, sediments, and for BOD loadings, which can result in heavy algal blooms and aesthetic nuisance conditions. Water quality must be considered in the operation of new reservoirs and in changes made in present operating procedures.

LOCATION MAP

SUBREGION 8

SUBREGION 8

LOWER COLUMBIA

INTRODUCTION

The Lower Columbia Subregion contains 5,103 square miles in the states of Washington and Oregon. The subregion consists of a portion of Columbia County, Oregon, and the drainage basin in Washington between Bonneville Dam and Grays Bay on the estuary. Rolling hills predominate in the western section, and the local relief is not great mostly less than 500 feet. The eastern portion is in the Cascade Range, with its rough topography rising to an elevation of over 14,000 feet.

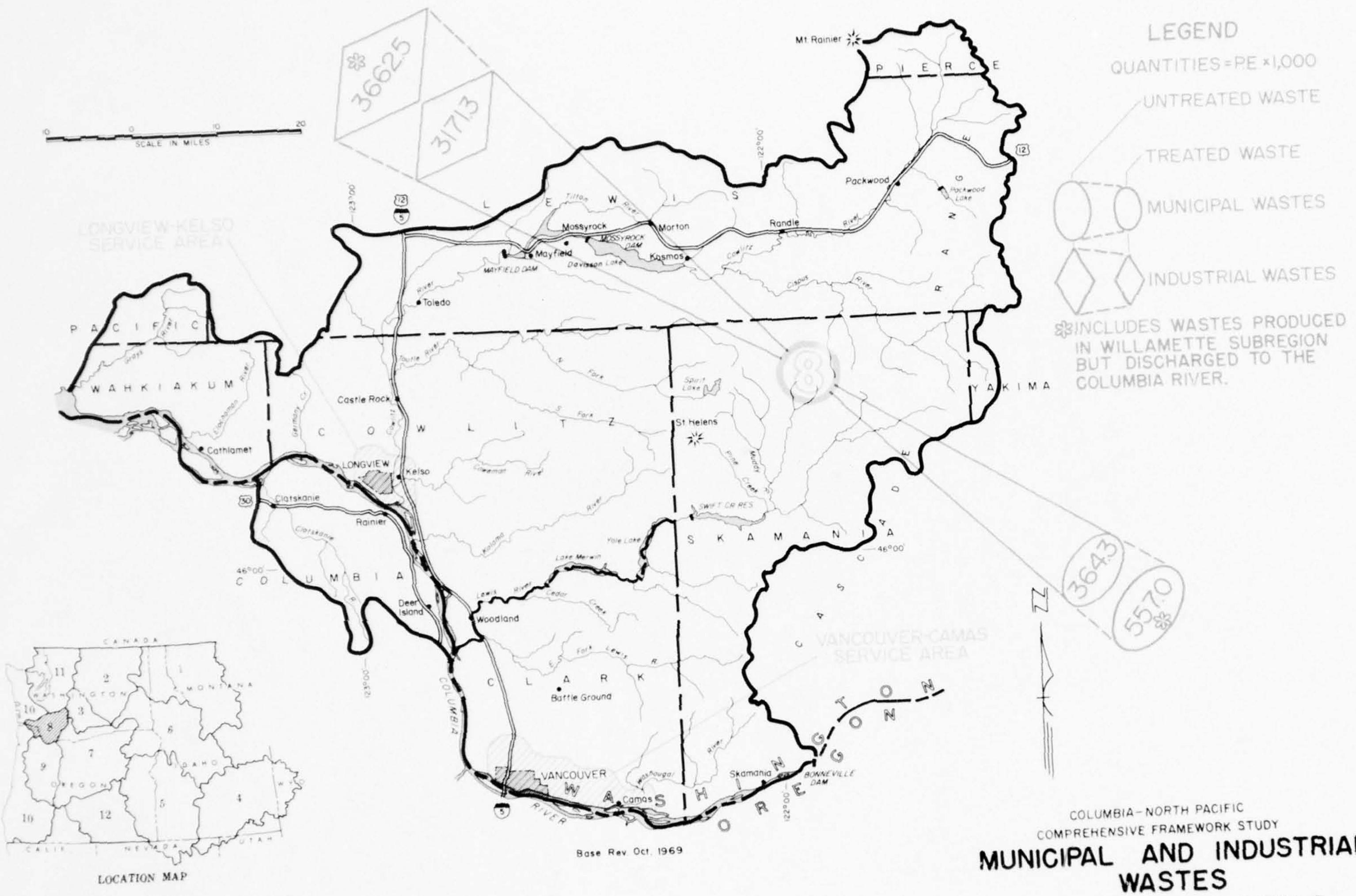
Average precipitation ranges from 40 to 100 inches between November and April, with light to sparse rainfall during the summer months. Temperatures are greatly modified by the ocean's influence, which easily reaches inland over the low Coast Range. Extreme temperatures of -20°F. to 107°F. (-28.9° to 41.7°C.) have been recorded.

There are several types of manufacturing plants in the subregion, such as pulp, paper, lumber, textile, and aluminum. The production of pulp and paper is the most important economic activity. Agriculture and agricultural processing plants are of relatively minor importance. Recreation is becoming increasingly important because of the nearness of the major metropolitan areas of Portland and Olympia-Tacoma.

The population of the subregion was about 220,250 persons in 1965. About 58 percent of the population are concentrated along the Columbia River in the Vancouver-Camas and Longview-Kelso Service Areas. Smaller communities are scattered through several valleys in the area.

PRESENT STATUS

A graphical summary of municipal and industrial waste production and discharge is presented in figure 85. About 18 percent of the waste loading is discharged to the Columbia River by municipalities and industries in the Willamette Subregion. The pulp and paper industry is the major contributor of organic wastes in the Lower Columbia Subregion. In addition, the pulp and paper, petro-chemical, and aluminum-refining industries discharge



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COMPREHENSIVE FRAMEWORK STUDY

MUNICIPAL AND INDUSTRIAL WASTES

LOWER COLUMBIA SUBREGION 8

1970

FIGURE 85

inorganic wastes that may be toxic. Other sources of pollution are relatively minor, although wastes from the rural-domestic population and from navigation and dredging activities can have important impacts on water quality in localized areas.

Although quality of the Main Stem Columbia is generally good, slime growths, attributable primarily to the pulp and paper industry, and bacterial pollution, resulting from municipal effluents, have created a serious problem. High water temperatures in the Lower Columbia have also been a cause for concern. Except for limited bacterial pollution in lower reaches and turbidity problems in glacier-derived streams, tributaries are generally of excellent quality.

Stream Characteristics

The two principal rivers, other than the Columbia River, in the Lower Columbia Subregion (the Cowlitz and Lewis Rivers) drain the western slope of the Cascade Range. The Cowlitz River derives from the glaciers of Mt. Rainier and Mt. Adams; the Lewis River originates in the glaciers of Mt. Adams only, with tributary streams draining the south and east slopes of Mt. St. Helens. The glaciers tend to regulate streamflow by accumulating and storing precipitation during cold, wet years and releasing more than average amounts of water during hot dry years.

The water resources of the Lower Columbia far exceed those of any other stream in the subregion. Although its regimen is affected somewhat by the precipitation pattern, melting snow and glacier fields in the Upper Columbia provide for well-sustained flows throughout the summer so there is always a considerable volume of water in the main stem.

Average annual runoff from the subregion amounts to about 24,971 cfs (18 million acre-feet). The mean annual runoff for the Columbia River at its mouth is 239,677 cfs (173 million acre-feet).

Surface-Water Hydrology

The discharge pattern of the Lower Columbia Subregion is characterized by minimum flows during the fall. Peak flows of tributary streams occur during winter and early spring when Columbia flows are lower. Table 107 summarizes monthly discharge data for selected stations.

From the standpoint of waste discharge control, the low-flow months of July, August, September, and October are the most important. In most of the subregion, August is the critical month. One-in-ten-year low flow is the selected recurrence frequency designated to describe critical low flows. These data for selected stations are presented in table 108.

Table 107 - Average Monthly Discharge, Subregion 8 (12)

Location	Jan.	Feb.	March	April	May	June	July (CFS)	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
Lewis River at Ariel, Wn.	8,145	7,610	4,745	4,472	3,814	3,379	1,948	1,232	1,196	3,548	8,223	8,410	4,752
E. Fork Lewis River near Heisson, Wn.	1,300	1,256	1,158	960	575	356	142	78	103	402	1,057	1,509	741
Cowlitz River at Packwood, Wn.	1,311	1,190	1,177	1,832	3,157	3,328	1,928	830	557	937	1,500	1,725	1,623
Cispus River near Randle, Wn.	1,259	1,146	1,210	2,057	2,627	2,123	1,057	548	412	600	1,168	1,612	1,318
Toutle River near Silver Lake, Wn.	3,076	2,922	2,554	2,440	2,139	1,737	909	500	494	1,018	2,395	2,896	1,923
Cowlitz River at Castle Rock, Wn.	12,436	14,884	8,434	8,774	9,646	9,559	5,515	2,951	3,014	4,719	12,177	15,078	8,932
Elochomin River nr. Cathlamet, Wn.	749	753	564	347	178	108	53	33	47	195	542	843	368
Columbia River at mouth	284,734	270,719	321,858	278,544	311,713	290,184	200,420	147,623	140,806	158,980	211,609	258,828	239,677

Table 108 - One-in-Ten-Year Low Flows, Subregion 8 1/ (12)

Stream and Location	One-in-Ten-Year Low Flow (cfs)
Lewis River at Ariel, Washington	600
East Fork Lewis River near Heisson, Washington	44
Cowlitz River at Packwood, Washington	290
Cispus River near Randle, Washington	270
Toutle River near Silver Lake, Washington	310
Cowlitz River at Castle Rock, Washington	2,200
Elochomin River near Cathlamet, Washington	140
Columbia River at mouth	120,000

1/ Period of 1 month.

Impoundments and Stream Regulation

The Cowlitz and Lewis Rivers have major impoundments, with Mayfield and Mossyrock Dams on the Cowlitz; and Merwin, Yale, and Swift Dams on the Lewis River. Although the reservoirs are primarily for power or for municipal and industrial water supply, considerable flood control is provided, and all of the reservoirs are used for recreation.

The effect of impoundments on water quality in the subregion is not considered to be a major problem at the present time. The dams are relatively new, and changes that may be occurring are still slight enough that they are difficult to detect. Because there are presently no major waste sources entering the streams above the reservoirs, there have been few reports of poor water quality.

Ground-Water Characteristics

Only one aquifer unit is of major importance in the utilization of ground water in Subregion 8. Large supplies of good quality water are obtained from alluvial deposits which form extensive benches and terraces in western Clark County and southern Lewis County. Narrower terraces occur elsewhere along the Lewis, Cowlitz, and Columbia Rivers. Where moderate thicknesses of clean sand and gravel are saturated, they will often yield over 500 gpm.

Except for some excessively saline water from marine sedimentary strata, the water is of excellent quality. Excessive iron has been reported in some alluvial deposits used for domestic purposes.

A more detailed discussion of ground water in Subregion 8 is presented in Appendix V.

Pollution Sources

The municipal and industrial waste loadings and discharges, in population equivalents, for the Lower Columbia Subregion are summarized in table 109. Included in the table are those waste sources originating in the Willamette Subregion but discharging to streams in the Lower Columbia Subregion.

Table 109 - Summary of Municipal and Industrial Waste Treatment, Subregion 8 [1/]

	Municipal					Industrial			
	Primary	Secondary	Lagoons	Other	Total	Pulp and Paper	Food Products	Misc.	Total
Lower Columbia Subregion									
Number of facilities	7	5	8	0	20	6	12	7	25
Population served	50,140	4,450	28,160	0	82,750				
PE untreated	70,940	4,850	33,230	0	109,020	3,265,000	32,000	12,500	3,309,500
PE treated	44,560	870	20,890	0	66,320	2,782,000	24,800	11,500	2,818,500
% removal efficiency	37	82	37	--	39	15	23	8	15
Others *									
Number of facilities	2	1	0	0	3	1	0	0	1
Population served	372,000	5,000			377,000				
PE untreated	442,000	6,000			448,000	353,000			353,000
PE treated	295,000	3,000			298,000	353,000			353,000
% removal efficiency	33	50			33	0			0
Total									
Number of facilities	9	6	8	0	23	7	12	7	[illegible]
Population served	422,140	9,450	28,160	0	459,750				
PE untreated	512,940	10,850	33,230	0	557,020	3,618,000	32,000	12,500	3,662,500
PE treated	339,560	3,870	20,890	0	364,320	3,135,000	24,800	11,500	3,171,300
% removal efficiency	34	65	37	--	35	14	23	8	14

* Includes wastes produced in Willamette Subregion but discharged to Columbia River
1/ FWPCA inventory of Municipal and Industrial Wastes, Lower Columbia Subregion, 1965.

At present, municipalities and industries discharging to subregion waterways produce wastes equivalent to those from a population of about 4.22 million persons. Approximately 3,420,000 PE originate from within the subregion and 800,000 PE from the Willamette Subregion. Of this total, 75 percent is generated by by the pulp and paper industry, 13 percent by municipalities, and the remaining 12 percent by the food-processing and miscellaneous industries.

Waste treatment and other means of waste reduction decrease the total organic load to the subregion's waters by about 16 percent, so that 3.54 million population equivalents actually reach waterways. Of this total, about 364,000 PE are released by municipalities, and 3,171,000 PE are discharged by industries.

Municipalities

Approximately 82,750 persons, or 38 percent of the Lower Columbia Subregion population, are served by municipal waste treatment facilities. Of 20 municipal waste sources, only five receive secondary treatment; however, several of these facilities require enlargement or replacement to handle present loads. Seven primary plants are provided by municipalities. All of these must convert to secondary treatment by September 30, 1972, to meet minimum requirements of Oregon and Washington Water Quality Standards. Lagoons are used by eight communities. In general, their operation has been satisfactory. Three municipal facilities

discharge significant waste loadings from the Willamette Subregion to the Lower Columbia River. In fact, the BOD loading released by the primary plant at Portland, Oregon, is four times that from all other municipalities in the Lower Columbia Subregion.

Municipalities in the Vancouver-Camas Service Area discharge an organic waste loading of about 36,000 PE. The City of Vancouver is the largest individual source, releasing about 30,000 PE from a primary treatment plant to the Columbia River. The facility becomes hydraulically overloaded even during periods of light rainfall because of combined sewers within the city. During this period, sewage bypassing directly to the Columbia River is practiced. Several industries also discharge effluent to the combined sewers after some type of screening. The Washington Water Quality Standards have listed Vancouver as needing secondary treatment, outfall extension, elimination of overflows, and improved disinfection. The unincorporated community of Hazel Dell, which presently operates an overloaded lagoon, plans to connect to the Vancouver system. Also, within the service area, Washougal discharges about 2,400 PE to the Columbia River after treatment in lagoons. Just below Washougal, along the Columbia River, the City of Camas releases to Camas Slough about 3,300 PE from its primary treatment plant.

The Longview-Kelso Service Area accounts for a municipal waste loading of about 28,000 PE to subregion waterways. The City of Longview has a primary treatment plant that needs improvement and recently completed a new lagoon to relieve a portion of the burden of the primary plant. The facilities release a combined waste loading of about 18,000 PE to the Columbia River. Kelso provides primary treatment of its municipal wastes, which results in a discharge of about 8,400 PE to the Coweeman River, a small tributary of the Cowlitz River.

Several municipal facilities in the Willamette Subregion discharge wastes to the Columbia River. Included are the effluents from the Gresham and Portland treatment plants, and from the sewage treatment plant at the Portland Airport. Gresham releases about 3,000 PE to the Columbia River. During the food-processing season from July to September, the organic load discharged increases to about 12,000 PE. The Portland Airport (River Mile 110) discharges about 900 PE to the Columbia River. The City of Portland (River Mile 105) discharges the largest municipal waste load to the Columbia River--about 294,600 PE. Expansion of the primary plant was completed in 1970. Addition of secondary treatment facilities is scheduled to be completed by June 1, 1972.

Most other communities in the Lower Columbia Subregion are relatively minor waste sources. In general, adequate secondary treatment or lagoons are provided. Only the towns of Kalama,

Woodland, and Ridgefield, in Washington, and Rainier, Oregon, which operates primary treatment facilities, have less than adequate treatment.

Industries

The pulp and paper industry is the major pollution source in the Lower Columbia Subregion. At present, an organic loading equivalent to that from a population of 3.14 million persons is discharged by the industry to subregion streams. This represents 89 percent of the total organic loading for the subregion. The 1965 Lower Columbia River Enforcement Conference concluded that wastes from pulp and paper mills are the principal source of the nutrient material required for slime growth. Also, it was found that wood fibers discharged by the mills added strength and body to the slimes and made them more difficult to remove from nets and sport-fishing gear. Since the conference, the pulp and paper industry has taken significant measures to improve the situation, including construction of primary treatment facilities at all mills and the active studying of chemical recovery and treatment methods by mills using the sulfite process.

A pulp and paper corporation at Camas, Washington, produces paper products by the sulfate, sulfite, and groundwood pulping processes. The conventional evaporation and burning recovery system is utilized for the sulfate process. Save-alls are used to recover usable fibers from the papermill white water. Groundwood mill effluents are reused in other mill operations. Primary treatment is provided to reduce the amount of fibers discharged by the mill. About 24,500 lbs./day of volatile suspended matter (VSM) are released to the Columbia River from the facility. The mill presently stores spent sulfite waste liquor in a lagoon for intermittent disposal (every 7th day) through a submerged outfall to the Columbia River. A total organic waste loading of about 1.63 million PE is released by the mill. The Washington Water Quality Standards and the 1965 Lower Columbia River Enforcement Conference required that they provide, by December 31, 1969, the necessary means to obtain 70 percent reduction in BOD loading presently discharged in spent sulfite waste liquor.

A paper company at Oregon City, Oregon, presently barges concentrated spent sulfite waste liquor for discharge into the Columbia River below the junction of the Willamette River during the critical flow season in the Willamette, usually from June to November. This represents an organic waste loading of 353,000 PE to the Columbia River. The Oregon State Sanitary Authority reports that this operation is to be discontinued by December 31, 1969.

A company at Longview, Washington, operates kraft, groundwood, and semi-chemical pulping processes for production of bleached and unbleached paper products. Normal in-plant control, chemical recovery procedures, and a primary settling facility are provided. The mill discharges about 14,300 lbs/day of volatile suspended matter and an organic loading of about 400,000 PE to the Columbia River.

A paper company at Longview, Washington, produces paper products from sulfate, sulfite, and semi-chemical pulping processes. Normal in-plant fiber and chemical recovery methods are used. Primary treatment is provided for partial removal of settleable solids and the BOD loading. The facility releases about 17,700 lbs./day of volatile suspended matter and an organic loading of 750,000 PE to the Columbia River. Frequent releases of water containing large quantities of chlorine occur at the mill, and fish kills have resulted. The Washington Water Pollution Control Commission is now working to correct this problem.

Small-scale pulp and paper operations in the subregion include a paper company and a pulp and paper company. The paper company operates a papermill at Longview, Washington, using raw pulp purchased from another company. The effluent from the plant is treated in a primary facility. The pulp and paper company operates a cottonwood pulp mill. An organic waste loading of about 2,000 PE is discharged directly to the Cowlitz River.

Food-processing wastes are seasonal in the Lower Columbia Subregion; the processing period for most of the fruits and vegetables is July through September. In general, no treatment of food-processing wastes is provided. Of the total organic waste load of 32,000 PE generated by the food-processing industry, only a 23 percent reduction is accomplished before discharge. In addition, a small portion of the wastes is discharged to municipal systems.

Solid wastes are collected at two food-processing plants in Vancouver by use of sumps and screens, and are disposed of on land. The liquid wastes pass screens and are then discharged to the Columbia River through a submerged outfall. The two food processors discharge an organic loading of 170,200 PE during the canning period. The Washington Water Quality Standards require that these firms be intercepted by the municipal system in Vancouver by September 30, 1972.

Little data are available concerning industrial wastes from the three aluminum-processing plants in the subregion. Depending on the processes employed, the wastes may be high in fluorides, cyanides, and inorganic solids, and may be of a high temperature.

An aluminum company at Troutdale, Oregon, is in the Willamette Subregion, but waste waters from the plant are discharged into waters of the Lower Columbia Subregion. Industrial wastes from the plant are discharged into two small ponds before entering the Columbia River. These ponds tend to reduce the temperature and remove settleable solids and oils. However, the apparent absence of fish life in these ponds, which are connected directly to the river through an open creek, indicates some toxicity.

An aluminum company at Vancouver operates a small lagoon for settleable solids and oil removal. Fluoride concentrations in the industrial effluent are above 80 mg/l, and large quantities of cooling water are released to the Columbia River. The Washington Water Quality Standards list the facilities as in need of modification or expansion by September 30, 1969.

A metal company at Longview has experienced problems with cyanides in its industrial effluent. The Washington Water Pollution Control Commission requires that cyanides be removed to an acceptable level by September 30, 1969.

Other industrial wastes of minor importance include washings from grain elevators, forest products plants, woolen mills, and dairies. In general, these industries provide adequate treatment of their wastes.

Rural-Domestic

Approximately 137,500 persons or 62.4 percent of the Lower Columbia Subregion's population, are served by individual sewage disposal systems. In general, septic tanks and some type of subsurface disposal are used by the rural-domestic population. The actual waste load reaching waterways is not considered to be large.

The only known problem area associated with the rural-domestic population is the discharge of untreated domestic wastes from houseboats along the Columbia River and several tributaries. On the Columbia River in the Portland-Vancouver area there are about 300 houseboats. This represents a population of between 500 and 1,000 persons. An additional area of houseboat concentration is at the confluence of the Lewis River with the Columbia. About 25 houseboats are in this area. The measurable organic and chemical pollution load from the houseboats is relatively small when compared with the total pollutional load discharged from all sources. However, aesthetic nuisance conditions resulting from floating materials and health hazards from pathogenic organisms

are considered to be the significant pollutional factor involved. The Oregon State Sanitary Authority and the Washington Water Pollution Control Commission are actively working on programs to eliminate this problem.

Navigation and Dredging

Use of the Columbia River for navigation has a degrading effect unless proper control measures are taken. Dredging materials from navigation channels and dock facilities often cause turbidity. When bottom materials are high in organics, oxygen depressions are also experienced. Dredging material is sometimes redeposited in other areas of the Columbia, creating similar problems. A policy of land disposal of dredging materials could ease the problem.

Another problem created by navigation is the discharge of untreated sewage from many large ships using the river. Occasionally oceangoing ships pump bilge water containing large quantities of oil into the river. The GPA, WQO Pacific Northwest Water Laboratory is currently studying this problem.

Others

Irrigation, agricultural animals, land use, recreation, and natural sources represent relatively minor sources of pollution in the Lower Columbia Subregion.

Present Water Quality

Only a relatively small amount of data has been collected for most reaches of the Lower Columbia, since quality monitoring agencies have budgetary limitations, and the Columbia River lies between two states. However, the state agencies have an ambitious water quality monitoring program for intrastate streams. Also, in conjunction with State Water Quality Standards, both Washington and Oregon have now begun regular sampling programs on the Columbia.

There are many conflicts among analyses from different agencies at comparable stations along the river. This is especially evident with respect to iron, phosphate, and nitrogen analyses and may be due to sampling or analytical techniques. In the future, efforts should be made to resolve such differences. For the present, inferences must be made from the existing data.

The Columbia's discharge ranks it as the fourth largest river in North America, and provides ample dilution capacity to

absorb impacts from its somewhat sparsely developed basin with few significant changes in water quality characteristics. The waters of the Lower Columbia are generally good from the standpoint of dissolved oxygen, color, turbidity, hardness, dissolved solids, biochemical oxygen demand, and radioactivity. Problems do occur in some reaches and seasons with respect to temperature, nutrient levels, and bacterial and biological contamination. Recently, concern has been raised concerning supersaturation of nitrogen as a significant problem affecting fisheries.

Main Stem Columbia River

The dissolved oxygen in all reaches of the Columbia River from Bonneville Dam to the mouth averages well above saturation, as shown in figure 73. The Oregon State Water Quality Standards provide that no wastes which cause dissolved oxygen levels to fall below 90 percent of saturation shall be discharged to the Columbia River. This condition is generally satisfied throughout the length of the Lower Columbia. The dissolved oxygen levels average above 9 mg/l D.O. at all stations on the main stem, and the minimum levels are above 6.5 mg/l D.O. Figure 74 shows a mean Columbia River dissolved oxygen profile.

Data for the Lower Columbia River show generally low BOD levels. FWPCA Water Surveillance Stations at Bonneville Dam and Clatskanie show average 5-day BOD values of 1.1 and 1.5 mg/l at River Miles 145.5 and 53.5, respectively. These low values, coupled with the generally satisfactory dissolved oxygen levels, indicate that BOD levels are not of problem proportions.

Coliform data for relatively few stations on the Lower Columbia River are available. Figure 75 shows a mean coliform profile of the river. Oregon and Washington State Water Quality Standards require that average coliform counts shall not exceed 240/100 ml between the Oregon-Washington boundary and the Interstate Bridge at Portland; and shall not exceed 1,000/100 ml from the Interstate Bridge to the mouth of the Columbia River. Available data show that the standards are met above the bridge but that coliform counts downstream from the Interstate Bridge are usually far in excess of 1,000/100 ml. The increase in coliform counts is attributed to domestic waste effluents in the Portland-Vancouver area.

Maintaining adequate temperature levels is one of the most significant problems complicating water resource management of the Columbia River today and will grow in importance as thermal powerplants are built. Elevated temperatures have detrimental effects on salmonid fisheries which make up a significant portion of the

economic resource of the Columbia Basin. For protection of anadromous fish migration, the Oregon and Washington temperature standards for the Columbia River permit no measurable increases in river temperatures from other than natural sources when such river temperatures are 68°F. (20°C.) or above. Figure 76 presents a temperature profile of the Lower Columbia River for the critical months of July, August, and September. Figure 77 shows the mean yearly variation in water temperatures at three stations along the river. Figures 76 and 77 show that summer water temperatures in the Columbia River exceed the state standards from Bonneville Dam to the mouth.

High levels of nutrients and trace elements contribute to nuisance sphaerotilus growths in the Lower Columbia River. Figure 78 shows nutrient and trace element levels for the Lower Columbia River. The concentrations of all of these factors are above limiting values for either algal or sphaerotilus growths. The high levels contribute to the well-documented sphaerotilus problem in the reaches between Camas and Astoria. The pulp mill wastes, together with favorable temperatures, currents, and nutrient levels, provide ideal ecological conditions for such sphaerotilus growths.

The potential for abnormally high, and perhaps even harmful, levels of radioactivity in the Columbia River, exists primarily as a consequence of discharges of the Hanford Atomic Works upstream from Richland, Washington. Levels of activity to date have not approached the danger level; and continuous monitoring by AEC and Battelle Northwest, supplemented by the states of Washington and Oregon and FWPCA, will provide adequate warning if a hazard develops.

Supersaturated levels of dissolved nitrogen as high as 140 percent have recently been reported by the Bureau of Commercial Fisheries. The condition persists all along the Columbia River from Grand Coulee Dam to the mouth and presents a threat to migratory salmonids. The supersaturation phenomenon is not well understood as yet, and no specific limits have been set for dissolved nitrogen in State Water Quality Standards. Any amount of nitrogen in excess of saturation may present a threat to migratory fish.

The main stem of the Columbia River shows relatively little variation in chemical quality in the reach from The Dalles Dam tothe estuary. The average dissolved solids content of samples collected at The Dalles Dam since 1958 is about 114 mg/l. Below Portland, Oregon, the dissolved solids content of the Columbia shows a slight decrease. The Willamette, Cowlitz, and Lewis Rivers have a combined average flow of about 20 percent of the

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total flow of the Columbia River and, being less mineralized than the Columbia River, tend to slightly decrease the average solute concentration of the river.

A salinity study in the Columbia River made by the Corps of Engineers in 1959 indicated that saltwater intrusion reaches at least 16 miles upstream from the mouth, and recent studies by Oregon State University indicate that the distance might be 23 miles. The maximum penetration of salt water was found during periods of low river flow.

Tributaries

The major tributaries in the Lower Columbia Subregion are the Washougal, Lewis, Kalama, Cowlitz, and Willamette Rivers. With the exception of the Willamette River, which will be discussed in the section on Subregion 9, the overall effect of the tributaries on the quality of the Main Stem Columbia is slight. Table 110 presents, for selected stations, a summary of physical, chemical, and bacteriological parameters important to water quality control.

The major tributaries originate on the west slopes of the Cascade Range. Most of this area is underlain by volcanic rocks which are resistant to solution. Consequently, all of the streams are low in dissolved minerals. The total dissolved solids concentrations of the water of most streams average less than 50 mg/l, and the average hardness is usually less than 20 mg/l. Calcium and bicarbonate are the predominant dissolved ions. The maximum dissolved solids concentration is usually less than 100 mg/l.

Many streams are turbid at certain times of the year, requiring treatment before the waters can be used for an industrial or a public supply. The Cowlitz River is nearly always milky in appearance because of silt associated with the glaciers of Mt. Rainier, Mt. St. Helens, and Mt. Adams. The Lewis River is less turbid because it drains only the southeast side of Mt. St. Helens and part of the west side of Mt. Adams.

Dissolved oxygen concentrations are satisfactory in most tributaries. Mean dissolved oxygen levels are generally above 10 mg/l. However, in the Coweeman River the dissolved oxygen level is depressed below 6 mg/l upstream from the Kelso sewage treatment plant during the summer low-flow period. The oxygen level below the treatment plant may be considerably lower.

Observed coliform densities indicate that few organisms are the general rule. Coweeman River is also the only stream exhibiting median coliform densities above the limit of 1,000 organisms/100 ml.

Summary of Problems

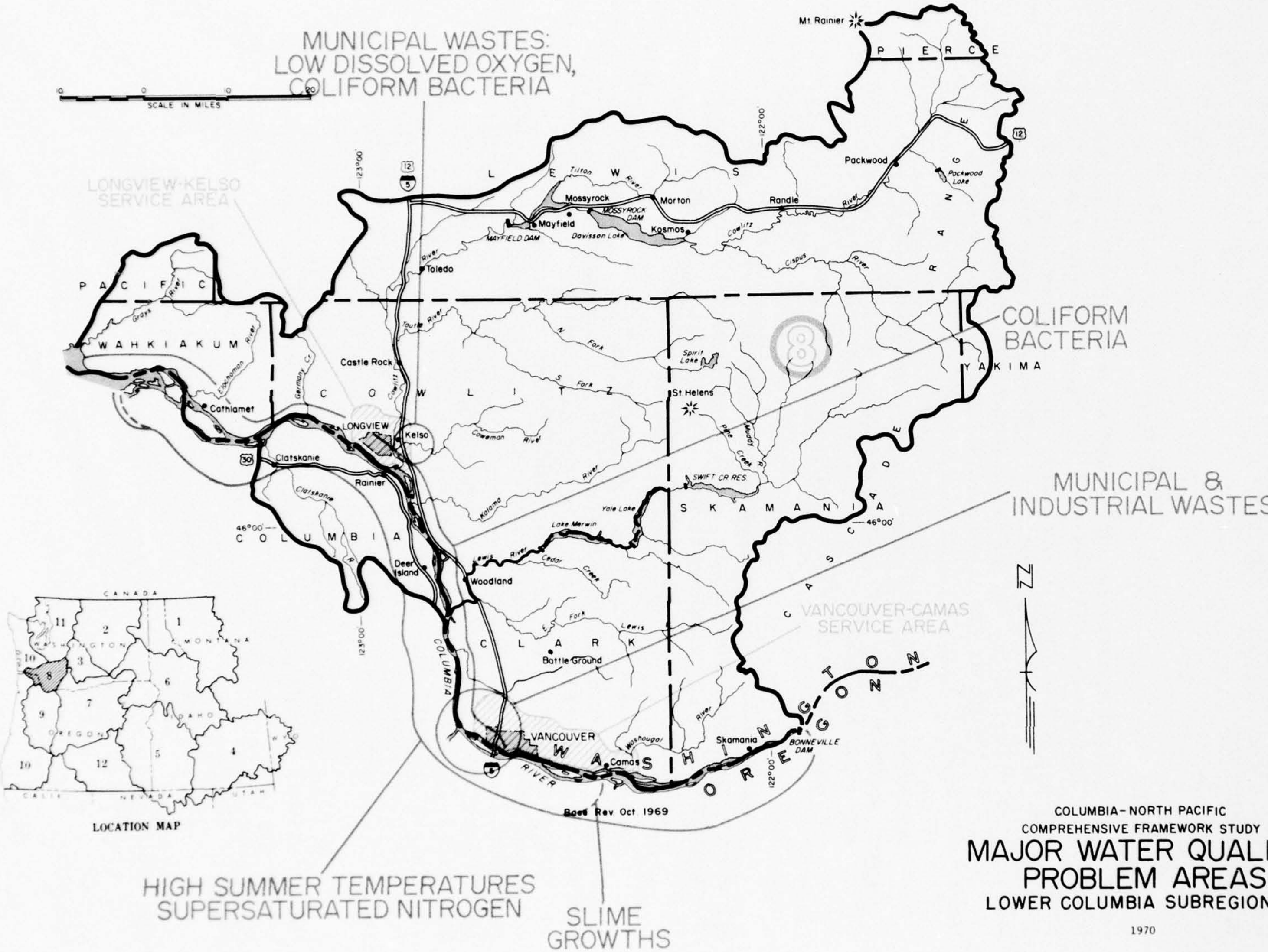
A graphical summary of water quality problem areas in the Lower Columbia Subregion is presented in figure 86. Most problems in the Lower Columbia River occur below the Vancouver-Camas and Portland Service Areas. However, the high water temperatures and supersaturated dissolved nitrogen concentration are conditions that persist throughout the Upper and Mid-Columbia, as well as the Lower Columbia River.

The summer temperature levels of the Columbia River are above recommended limits for fish migration. While high water temperatures in the Columbia River are primarily from natural causes, the Hanford Atomic Works discharges large quantities of waste heat.

The Columbia River contains supersaturated levels of dissolved nitrogen gas, which causes gas-bubble disease in fish. The supersaturation phenomenon is not well understood as yet, especially its persistence throughout the Lower Columbia.

For more than 25 years the quality of the Lower Columbia River has been adversely affected by slime growths which flourish periodically. The slime is a biological mass combined with varying amounts of fiber, debris, and sand. Wastes from the pulp and paper industry are primarily, but not wholly, responsible for the slime problem. Nutrients from municipal sewage also contribute to the problem. Nets become coated with these slime masses, and commercial fishermen must frequently cease fishing to clean them or be highly selective in placing them. Sport fishing and other forms of water-contact recreation have also been adversely affected by the slime growths.

The bacteriological quality of the Columbia River below the Interstate Bridge between Portland and Vancouver exceeds the limits specified in the Oregon and Washington Water Quality Standards. Inadequately treated municipal wastes from the Portland and Vancouver sewage treatment plants are the major cause of the problem. Raw domestic sewage from houseboats, pleasure boats, and ships is also presently discharged to the Lower Columbia. These wastes probably do not contribute significantly to the high coliform levels, but they do constitute a health hazard from pathogenic organisms and a nuisance condition resulting from floating materials.



COLUMBIA–NORTH PACIFIC
COMPREHENSIVE FRAMEWORK STUDY

MAJOR WATER QUALITY
PROBLEM AREAS

LOWER COLUMBIA SUBREGION 8

1970

FIGURE 86

Table 110 - Summary of Water Quality Data for Tributaries, Subregion 8[1/]

	River Mile	D.O. (mg/1)	T (^oC)	Coliform MPN/100ml	pH	Color PT-CO Units	Hard. (mg/1)	Turb. (JTU)	TDS (mg/1)	Ortho PO_4 (mg/1)	NO_3-N (mg/1)
Washougal River	120.7-9.7										
Mean		-	-	-	6.9	4	8	1	25	0.027	0.08
Min.		-	-	-	6.3	0	6	0	20	0.01	0.02
Max.		-	-	-	7.2	10	11	5	34	0.06	0.27
Lewis River	87.0-5.2										
Mean		11.1	10.1	177	7.0	3	13	3	34	0.017	0.06
Min.		9.0	5.0	0	6.7	0	10	0	27	0.00	0.00
Max.		13.8	20.0	930	7.4	5	16	10	40	0.04	0.25
Lewis River	87.0-19.5										
Mean		10.8	9.1	3	6.9	4	11	-	32	0.013	0.026
Min.		8.3	5.0	0	6.5	0	10	-	29	0.00	0.00
Max.		12.4	13.0	36	7.4	5	12	-	38	0.03	0.05
Kalama River	73.1-1.3										
Mean		11.2	10.1	723	7.2	5	15	3	42	0.046	0.11
Min.		8.2	2.9	0	6.8	0	10	0	31	0.00	0.00
Max.		13.2	17.9	11,000	7.5	10	19	20	54	0.17	0.52
Cowlitz River	68.0-4.8										
Mean		10.9	10.7	178	7.2	6	19	9	45	0.029	0.07
Min.		8.0	2.8	0	6.8	0	12	0	30	0.00	0.00
Max.		14.4	21.7	930	7.6	20	27	65	61	0.06	0.23
Cowlitz River	68.0-29.8										
Mean		11.4	9.9	134	7.2	6	19	10	44	0.021	0.07
Min.		8.8	2.8	0	6.9	0	12	0	30	0.00	0.00
Max.		15.1	21.5	930	7.8	20	28	85	57	0.06	0.25
Cowlitz River	68.0-76.2										
Mean		11.4	8.8	67	7.3	5	20	8	43	0.028	0.03
Min.		9.2	1.1	0	7.0	0	12	0	30	0.00	0.00
Max.		13.6	18.0	360	7.7	20	26	50	58	0.08	0.09
Coweeman River	68.0-1.4-2.6										
Mean		10.6	11.1	1,819	7.0	9	20	6	49	0.044	0.31
Min.		5.6	3.5	0	6.4	5	12	0	37	0.01	0.09
Max.		13.8	23.2	24,000	7.5	20	36	20	70	0.27	0.68

1/ FWPCA STORET, 1968.

Inadequately treated municipal wastes from the City of Kelso, agricultural runoff, and drainages from sloughs contribute to low dissolved oxygen levels, bacteriological problems, and nuisance aesthetic conditions in the Coweeman River.

FUTURE WATER QUALITY MANAGEMENT NEEDS

Based on the projected economic development of the Lower Columbia Subregion, the population is expected to increase from 220,250 in 1965 to 414,300 in 2020. This is an increase of 100 percent for the subregion compared with 121 percent for the region.

Figure 87 shows the projected subregion and service area populations for years 1980, 2000, and 2020. Municipal and rural population projections are tabulated in table 111. By 2020, over one-half of the subregion's population is expected to be located in the Vancouver-Camas Service Area. The Longview-Kelso Service Area will account for over 25 percent.

Table 111 - Projected Population, Subregion 8 1/

	1980	2000	2020
		(thousands)	
Vancouver-Camas Service Area	119.3	163.6	223.7
Municipal	91.7	149.9	223.7
Rural	27.6	13.7	--
Longview-Kelso Service Area	60.4	79.8	109.2
Municipal	48.9	73.9	109.2
Rural	11.5	5.9	--
Other	75.2	81.0	81.4
Municipal	16.0	21.6	25.5
Rural	59.2	59.4	55.9
Total Subregion	254.9	324.4	414.3
Municipal	156.6	245.4	358.4
Rural	98.3	79.0	55.9

1/ Derived from Economic Base and Projections, Appendix VI, Columbia-North Pacific Framework Study, January 1971 and from North Pacific Division Corps of Engineers data. Differences between totals in this table and source are due to differences in subregion boundaries. The source is based on economic boundaries and this table is based on hydrologic boundaries. The municipal population is defined as that population discharging wastes to a municipal sewerage system. The rural population is defined as the residual.

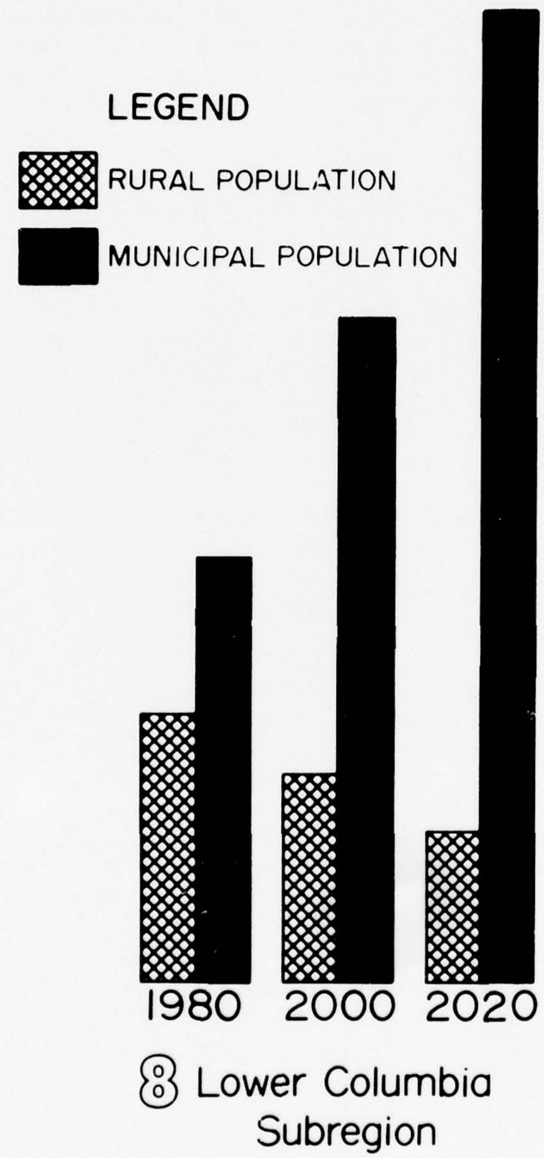


FIGURE 87. Projected Population, Subregion 8

Industrial development in the future will continue to be based on the subregion's abundant forest resources. All water using industries except lumber and wood products industry are expected to at least double production by 2020. The pulp and paper industry will continue to remain the largest producer of organic waste. Aluminum will lead in the production of primary metals.

Future Waste Production

Municipal

The projected municipal raw waste production for the Lower Columbia Subregion is presented in table 112. The population served by municipal waste collection and treatment systems is expected to increase from 56 percent in 1965 to 87 percent by the year 2020. It has been assumed that the entire populations of the two service areas will be served by municipal systems at that time.

Table 112 - Projected Municipal Raw Organic Waste Production
Subregion 8 1/

	1970	1980	2000	2020
		(1,000's P.E.)		
Vancouver-Camas Service Area	69.4	114.6	187.4	279.6
Longview-Kelso Service Area	46.8	61.1	92.4	136.5
Other	18.0	20.0	27.0	31.9
TOTAL SUBREGION	134.2	195.7	306.8	448.0

1/ A factor of 1.25 was applied to the municipal population components to account for the effects of small commercial establishments and other urban activities which add to municipal waste loads.

The service areas are expected to produce 93 percent of the subregion's municipal waste loading in 2020 as compared with 90 percent in 1965.

Industrial

Projected raw organic waste loadings for the major industrial categories are presented in table 113 for the years 1980, 2000, and 2020. By the end of the projection period, it is expected that industries will contribute approximately 93 percent of the subregion's total organic waste loading. The pulp and paper industry will continue to be the largest organic waste source, contributing approximately 98 percent of the industrial waste production. The

aluminum industry will be the major source of inorganic fluorides, cyanides, and inorganic solids; these discharges may be of a high temperature.

Table 113 - Projected Industrial Raw Organic Waste Production Subregion 8 1/ (5) (17)

	1970	1980	2000	2020
		(1,000's P.E.)		
Pulp and Paper	3,726.7	4,650.0	6,780.0	7,440.0
Food Products	37.3	48.0	69.0	95.0
Other	12.2	11.5	12.0	12.5
TOTAL	3,776.2	4,709.5	6,861.0	7,547.5

1/ Base data from FWPCA Inventory of Municipal and Industrial Wastes, Lower Columbia Subregion, 1965.

Generally, increases in waste production will occur from expansion of existing operations for most industries.

Rural-Domestic

The projected rural-domestic waste production is summarized in table 114 for the years 1980, 2000, and 2020. The rural-domestic waste production was assumed to be equal to the rural population component shown in table 111. The rural domestic waste production is expected to significantly decrease during the projection period.

Table 114 - Projected Rural Domestic Raw Organic Waste Production, Subregion 8

	1970 1/	1980	2000	2020
		(1,000's P.E.)		
TOTAL SUBREGION	124.4	98.3	79.0	55.9

1/ Interpolated from 1965 data and 1980 projections.

Irrigation

In 1966, there were approximately 18,000 acres of land irrigated, requiring an annual farm delivery of approximately 27,000 acre-feet from surface and ground-water sources. Irrigated acreage is projected to increase to 60,000 acres by 1980, 70,000 acres by 2000, and 100,000 acres by 2020. The farm delivery

requirement is expected to increase from 27,000 acre-feet annually in 1966 to 220,000 acre-feet annually by 2020.

Other Land Uses

Projections of land use in the subregion, by major types of land are shown in table 115.

Table 115 - Present and Projected Land Use, Subregion 8 (5)

	1966	1980	2000	2020
		(thousands of acres)		
Land Use				
Cropland	201	176	145	134
Irrigated	(17)	(54)	(66)	(98)
Nonirrigated	(184)	(122)	(79)	(36)
Forest	2,665	2,652	2,649	2,618
Range 1/	68	65	60	60
Other 2/	259	282	312	344
Total	3,193	3,175	3,166	3,156

1/ Does not include forest range.
2/ Includes barren land, roads, railroads, small water areas, urban and industrial areas, farmsteads, etc.

The urban dwellers as well as the farmers of the area use increasing amounts of petroleum products, fertilizing minerals, and toxic substances such as organic and inorganic pesticides. These constituents carried in the water draining from the land could result in significant water quality degradation.

Agricultural Animals

Farm animals produce large amounts of waste. The raw organic waste production by the livestock population in the subregion is expected to be equivalent to that from a population of 1,500,000 in 1980, 2,300,000 in 2000, and 3,100,000 in 2020. This would account for approximately 28 percent of the total raw organic waste production for the subregion by 2020. Most of this waste remains on the land; however, rains and irrigation water flush part of it into streams.

It is expected that a higher percentage of the cattle will be on feedlots by the year 2020 than at present. Dairies, feedlots, and other animal concentrations along streams cause accelerated erosion as well as intensifying the potential coliform bacteria, nutrients, and biochemical oxygen demand in the water.

Recreation

The projected raw waste production by recreation activities in the subregion are summarized as follows:

Year	Population Equivalents 1/
1970	31,000
1980	43,000
2000	77,500
2020	143,000

1/ Bureau of Outdoor Recreation and U.S.D.A. Forest Service Projections for total man recreation days (TMRD).

In the determination of wastes from recreation activities, the population equivalent is based on the total annual recreation days. The above values represent the daily raw waste production for a typical summer weekend.

Other Factors Influencing Quality

Thermal powerplants are producers of large quantities of waste heat and if discharged to the surface waters, the quality of the water is affected. Warm waters are unsuitable for fish passage and increase the rate of algal production.

A nuclear powerplant is under construction in the Rainier area; however, the heat is not permitted to be discharged to surface waters. Cooling towers, evaporating pond or some means must be employed to cool the water if returned to the Columbia River. In addition, a danger of accidental release of radioactive materials to the environment exists.

Quality Goals

Washington and Oregon have established water quality standards for both intrastate and interstate waters. These standards are the basis for the water quality goals in this study.

In establishing the water quality standards, each stream was classified as to its intended use and criteria set to protect these uses through quality levels which must be maintained. In addition, the standards incorporate an anti-degradation provision by requiring that waters whose existing quality is better than the established standards be maintained at the existing higher quality level. This means that the highest and best treatment under existing technology should be applied to all waste discharges.

The common parameters generally used are dissolved oxygen concentrations, temperature, turbidity, and coliform density. The water quality standards are summarized in table 116.

Table 117, taken from the Washington Water Quality Standards, shows the water classification and use of major streams in the subregion.

Table 116 - Water Classification and Criteria, Subregion 8 (Washington)

Water Quality Parameters		Class AA Extraordinary	Class A Excellent	Class B Good
Coliform		50 MPN	240 MPN	1,000 MPN
Dissolved oxygen		9.5 mg/1	8.0 mg/1	6.5 mg/1
Temperature*		60°F.	65°F.	70°F.
pH		6.5-8.5	6.5-8.5	6.5-8.5
Turbidity		5 JTU	5 JTU	10 JTU
Aesthetic values	-	Shall not be impaired by the presence of materials or their effects, excluding those of natural origin, which offend the sense of sight, smell, touch, or taste.		

*For all classes, the permissible increase in temperature over natural conditions is less than 1.8°F.

Water Quality Criteria, Subregion 8 (Oregon)

Coliform	240/100 ml
Dissolved oxygen	90% low flow and 95% during spawning.
Temperature	2°F. increase below 56°F.
pH	7.0 to 8.5
Turbidity	10% increase when natural turbidity is over 30 JTU; below 30 JTU, no increase.

MEANS TO SATISFY DEMANDS

Preserving water quality in the Lower Columbia Subregion to adequately support the river system's function will require a coordinated program of waste-controlling techniques, and development of a system of cooperative management of the subregion for pollution control. The attainment of adequate water quality will require an efficient, adequately staffed, and funded water quality management system for attacking the water pollution problem.

Waste Treatment

Future Waste Discharges

Water quality control in the subregion is largely dependent on providing adequate municipal and industrial waste treatment. If additional requirements and actions become necessary to attain the desired quality levels, the standards and implementation will have to be revised accordingly.

Table 117 - Water Classification and Use, Subregion 8 (15)

Legend

AA - Extraordinary
A - Excellent
L - Light
M - Moderate
H - Heavy

Watercourse	Assigned Class (Tentative)	Present - Future	Commercial & Game Fish: Salmonid Migration	Salmonid Rearing	Salmonid Spawning	Warm Water Fish Rearing	Warm Water Fish Spawning	Shellfish	Wildlife	Recreation: Water Contact	Boating & Fishing	Aesthetics	Water Supply: Domestic	Industrial	Agricultural	Navigation	Log Storage & Rafting	Electrical Power
Cowlitz River from mouth to Gifford Pinchot National Forest boundary	A	P	H	H	H	L	L	M	M	H	H	H	M	M	M	L	L	H
		F	H	H	H	L	L	M	M	H	H	H	H	H	H	M	L	H
Cispus River	AA	P	H	H	H				H	L	H	H						
		F	H	H	H				H	L	H	H						
Toutle River from mouth to Green River	A	P	H	H	H			L	H	M	H	M	L					
		F	H	H	H			L	H	H	H	H	M		L			
Toutle River (North Fork) from Green River to headwaters	A	P	H	H	H			L	H	M	H							
		F	H	H	H			L	H	H	H							
Green River from mouth to headwaters	AA	P	H	H	H			L	H	L	M	H						
		F	H	H	H			L	H	M	H	H						
South Fork of Toutle River from mouth to headwaters	AA	P	H	H	H				H	L	H	H	L					
		F	H	H	H				H	L	H	H						
Coweeman River from mouth to Mulholland Creek	A	P	H	H	H	L	L	L	M	M	H	M	L		M			
		F	H	H	H	L	L	L	M	H	H	H	M		M			
Coweeman River from Mulholland Creek to headwaters	AA	P	H	H	H				H	L	H	H						
		F	H	H	H				H	L	H	H						
Kalama River from mouth to Lower Kalama River Falls	A	P	H	H	H			L	H	H	H	H	M		L			
		F	H	H	H			L	H	H	H	H	H		M			
Kalama River from Lower Kalama River to headwaters	AA	P	H	H	H			L	H	L	H	H	L					
			H	H	H			L	H	M	H	H	M					
Lewis River from mouth to Merwin Dam	A	P	H	H	H	L	L	L	H	H	H	H	L	L	H			H
		F	H	H	H	L	L	L	H	H	H	H	H	M	H			H
East Fork of Lewis River from mouth to Multon Falls	A	P	H	H	H	L	L	L	H	H	H	H	L	M	H			
		F	H	H	H	L	L	L	H	H	H	H	M	H	H			
East Fork of Lewis River from Multon Falls to headwaters	AA	P	H	H	H				H	L	H	H	L					
		F	H	H	H				H	L	H	H	L					
Washougal River	A	P	H	H	H			L	H	H	H	H	M		M			L
		F	H	H	H			L	H	H	H	H	M		M			L
Grays River from mouth to Grays River Falls	A	P	H	H	H			L	H	L	H	M						
		F	H	H	H			L	H	M	H	H						H
Grays River from Grays River Falls to headwaters	AA	P	H	H	H			L	H		H	M						
		F	H	H	H			L	H	L	H	H						
Elochoman River	A	P	H	H	H			L	H	M	H	H			L			
		F	H	H	H			L	H	H	H	H	L	L	M			

Based on the treatment levels described in the Regional Summary and on raw waste projections presented earlier, the projected municipal waste loadings to be discharged to the waters are shown in table 118. The industrial waste loadings for major industrial categories are presented in table 119. The total municipal and industrial organic waste discharge is expected to be 735,800 PE in 1980, 716,700 PE in 2000, and 799,600 PE in 2020.

Table 118 - Projected Municipal Organic Waste Discharges, Subregion 8

	1980	2000	2020
		(1,000's P.E.)	
Vancouver-Camas Service Area	17.2	18.7	28.0
Longview-Kelso Service Area	9.2	9.2	13.6
Other	3.0	2.7	3.2
TOTAL SUBREGION	29.4	30.6	44.8

Table 119 - Projected Industrial Organic Waste Discharges, Subregion 8

	1980	2000	2020
		(1,000's P.E.)	
Pulp and Paper	697.5	678.0	744.0
Food Products	7.2	6.9	9.5
Other	1.7	1.2	1.3
TOTAL	706.4	686.1	754.8

By 2020, approximately 63 percent of the municipal waste loading in the subregion is expected to be from the Vancouver-Camas Service Area. The Longview-Kelso Service Area will account for an additional 30 percent. The pulp and paper industry will be the largest industrial discharger of organic waste material, discharging approximately 93 percent of the subregion's organic waste to the surface waters.

Treatment Costs

Curves showing estimated costs of constructing (total capital) and operating (annual operation and maintenance) municipal sewage treatment plants for various treatment levels are presented in the "Means to Satisfy Demands" section of the Regional Summary.

Other Pollution Control Practices

Some of the water quality problems of the Lower Columbia Subregion are beyond the reach of conventional waste treatment and flow regulation. Solution to the problems is not as clear-cut but is just as important in maintaining water quality.

Wastes from pulp and papermills are the principal source of nutrient material required for slime growths according to the 1965 Lower Columbia River Enforcement Conference. The pulp and paper industry has taken significant measures to improve the situation including construction of primary treatment facilities at all mills and the active studying of chemical recovery and treatment methods by mills using the sulfite process. Continued surveillance is necessary to assure the methods are employed for nutrient removal in the discharges.

Future power demands are dictating the need for thermal powerplants to be constructed. Excess heat will not be discharged to the rivers. Themal powerplants will be required to cool waste water before discharge into surface streams and flow-through cooling will be no longer permitted. Other influences are heavy metals or toxic substances in the cooling water and accidental radioactive discharges.

Recreation areas will be increasing in numbers, size, and intensity throughout the subregion. Sewage disposal systems adequate to cope with weekend loads will be needed in many recreation areas. Facilities for collection and pickup of litter and garbage must also be made available, since these things add to the waterborne debris load.

Minimum Flow Requirements

A set of generalized curves showing minimum flow requirements for waste loadings subjected to various treatment levels is presented in figures 88 and 89 for several dissolved oxygen objectives, elevations, and self-purification factors (a combined characteristic of the waste and stream). Figure 90 shows generalized areas for which particular graphs are applicable. These figures give only approximate requirements for small to middle-sized communities with a normal mix of municipal and industrial wastes.

Vancouver-Camas Service Area The population of the Vancouver-Camas Service Area is expected to increase from 81,500 in 1965 to 223,700 in 2020. The pulp and paper industry will represent the major waste source, with an estimated raw waste

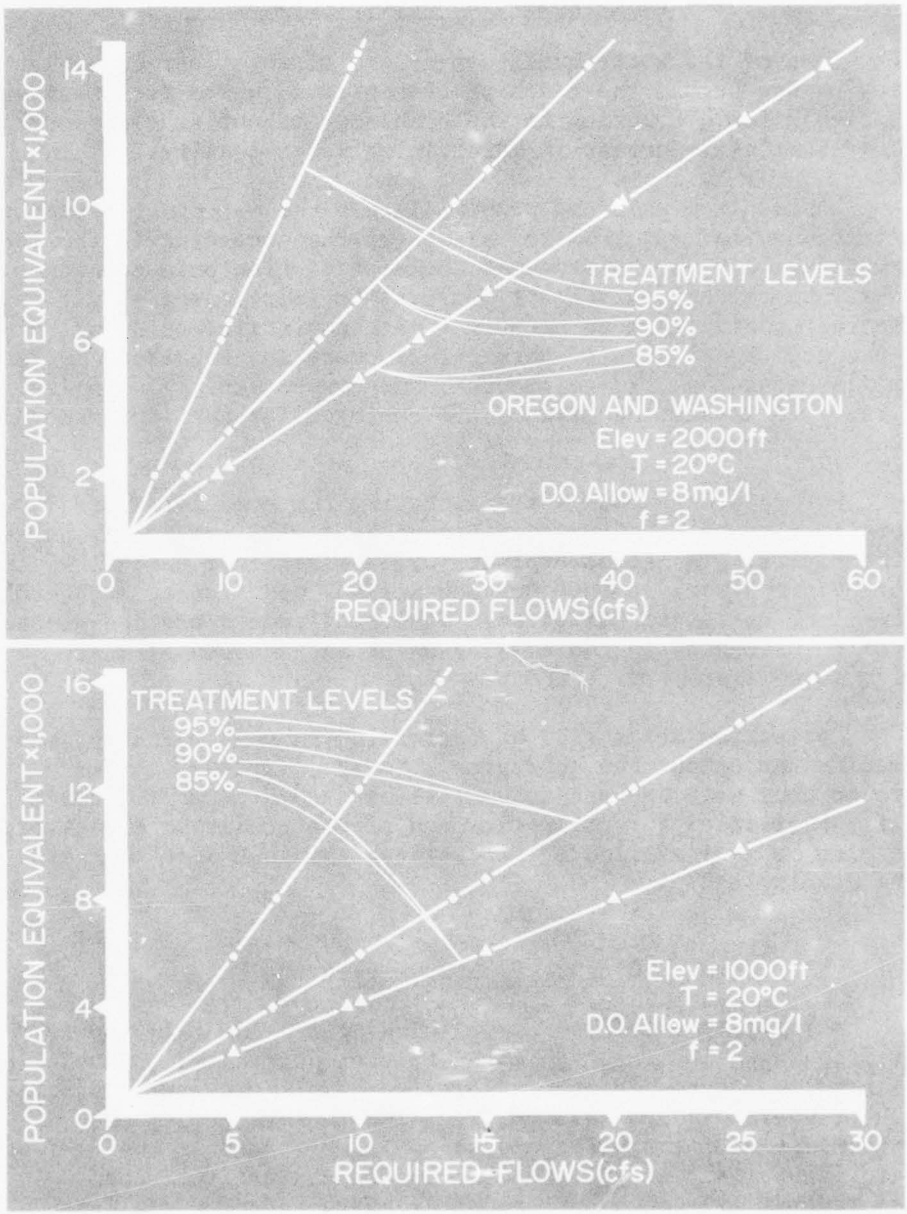


FIGURE 88. Minimum Flow Needs to Maintain Oregon and Washington Dissolved Oxygen Standards Criteria (Elevations 2000 and 1000 feet)

production of 2,800,000 PE in 1980 and 4,400,000 PE in 2020. Food processing industries are expected to produce approximately 300,000 PE in 1980 and 580,000 PE in 2020.

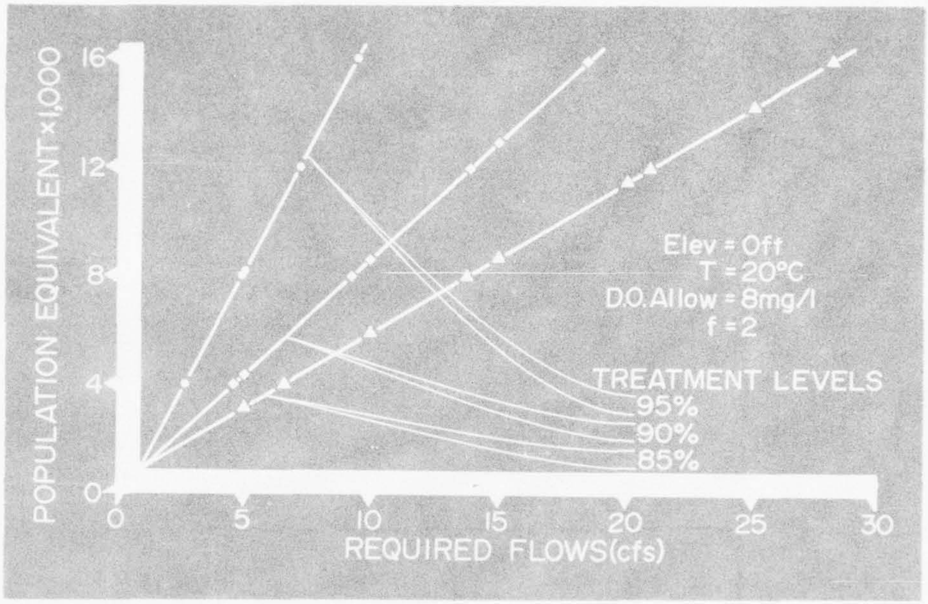


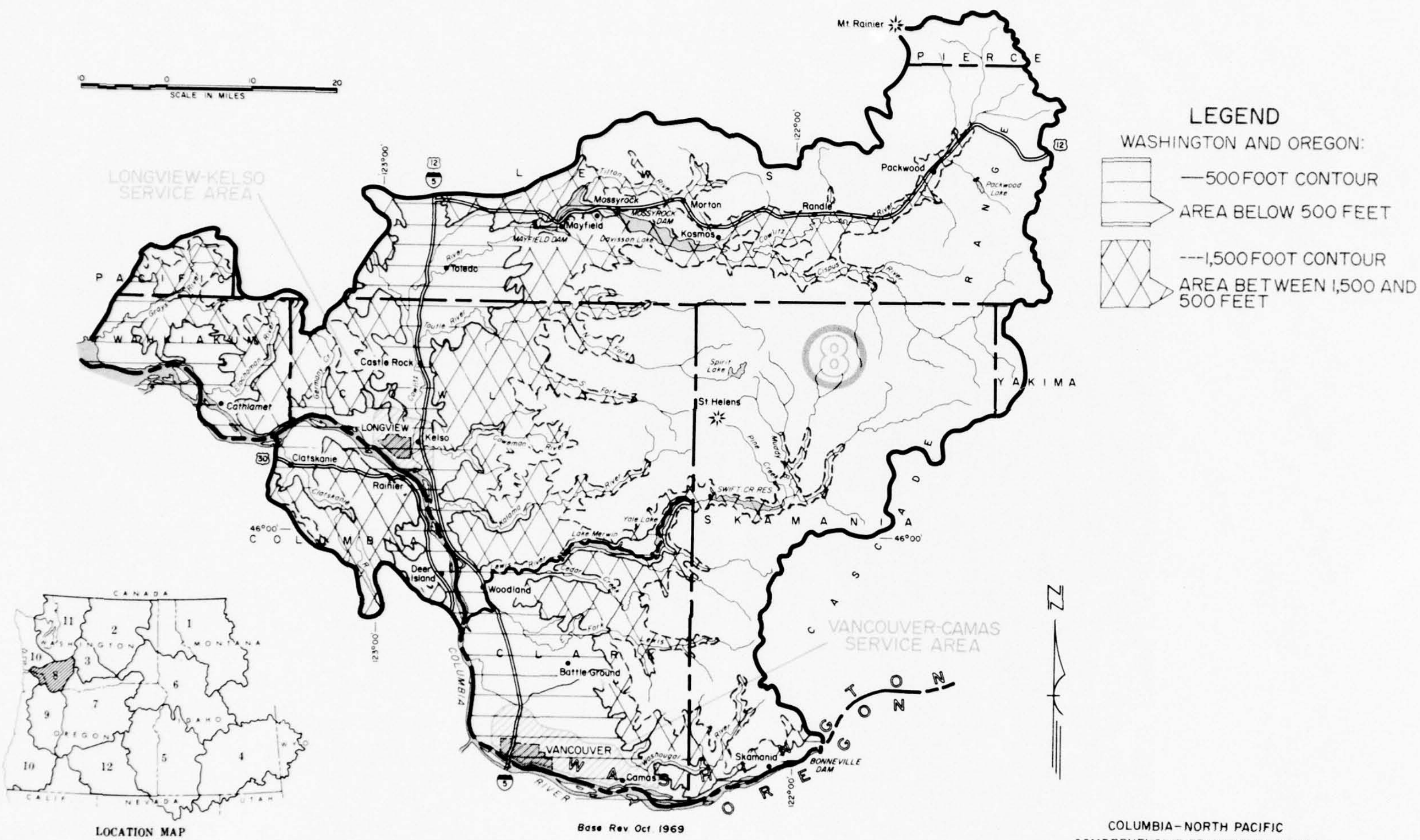
FIGURE 89. Minimum Flow Needs to Maintain Oregon and Washington Dissolved Oxygen Standards Criteria (Sea Level)

Longview-Kelso Service Area

The population of the Longview-Kelso Service Area is expected to increase from 32,000 in 1965 to 109,200 in 2020. The pulp and paper industry will represent the major waste source, with an estimated raw waste production of 2,000,000 PE in 1980 and 3,100,000 PE in 2020.

Other Minimum Flow Requirements

In the preceding section, only oxygen demanding wastes from controllable sources were considered in developing the set of generalized curves for determining minimum streamflows. Wastes from irrigation return flows, feedlots, and other non-point sources also deteriorate water quality by contributing organics, nutrients, coliform bacteria, turbidity and increasing water



COLUMBIA–NORTH PACIFIC
COMPREHENSIVE FRAMEWORK STUDY

AREAS TO WHICH FIGURES 88 AND 89 APPLY
LOWER COLUMBIA SUBREGION 8

1970

FIGURE 90

temperature. In addition, a variety of chemical substances are applied to the lands for such purposes as insect and weed control. These chemicals are easily flushed into streams and are toxic to the stream biota.

Management Practices

The management of the water resources of the Lower Columbia Subregion is an important factor in preserving water quality of the streams and rivers. Detailed planning and adequate financing are required so as to prevent potential water pollution which would otherwise result from increasing waste loadings. Water quality must be considered in the planning and operation of all new reservoirs and in changes made in present operating procedures. Dependable flows must be guaranteed.

LOCATION MAP

SUBREGION 9

S U B R E G I O N 9

W I L L A M E T T E

INTRODUCTION

The Willamette Subregion is divided in terms of significant subbasins and major service areas. The three major subbasins are the Upper Willamette, Middle Willamette, and Lower Willamette. The major service areas within the subregion are the Eugene-Springfield, Albany-Corvallis, Salem, and Portland areas.

PRESENT STATUS

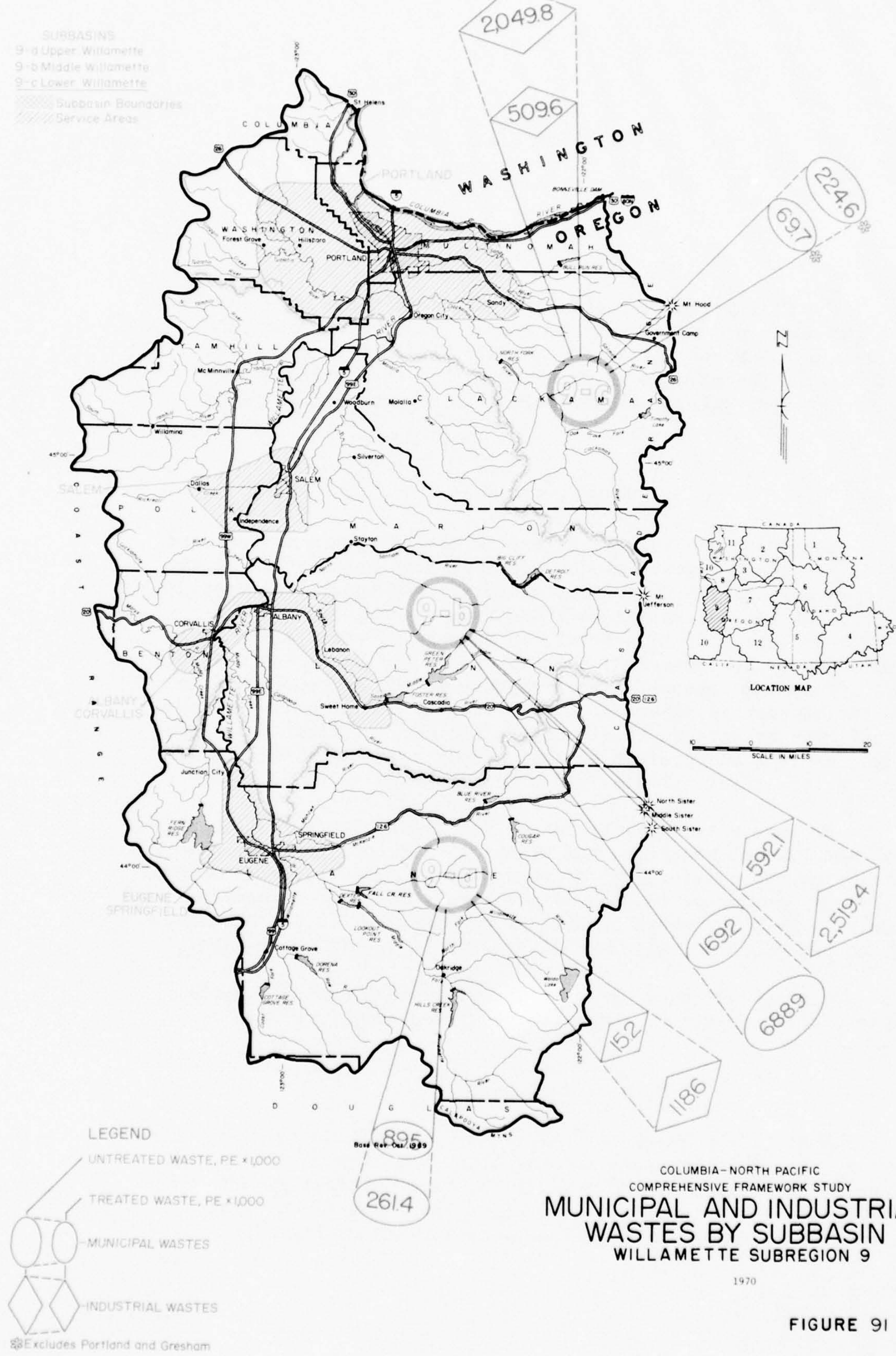
Municipal and industrial wastes discharged to streams and rivers are the primary cause of water quality degradation in the Willamette Subregion. In 1965, municipal and industrial sources produced wastes equivalent to those from a population of 5.9 million persons. Of this total, an average of about 1.4 million population equivalents (PE) actually reach the subregion's waterways. Pulp and papermills are responsible for 96 percent of the industrial waste discharges. Other sources of pollution having significant effects on water quality include: irrigation return flows, rafting and storage of logs, dredging, recreation activities, agricultural animals, and urban drainage.

Average water quality in the Willamette Subregion is, with the exception of bacterial pollution, at a generally acceptable level. However, water quality conditions in many streams become a serious problem during the summer months when low streamflow occurs. The most severe conditions are apparent in the Portland Harbor reach of the Willamette River and in the Tualatin River.

A graphical summary of municipal and industrial organic waste production and discharge is presented in figure 91.

Stream Characteristics

Most of the major tributaries of the Willamette River rise in the Cascade Range, entering the main stem from the east. All of the streams are derived principally from rainfall runoff, with varying degrees of snowmelt included. The flood flows of the Willamette River system are largely controlled by reservoirs, with



COLUMBIA–NORTH PACIFIC
COMPREHENSIVE FRAMEWORK STUDY

MUNICIPAL AND INDUSTRIAL WASTES BY SUBBASIN

WILLAMETTE SUBREGION 9

1970

FIGURE 91

three on the Santiam, two on the McKenzie, three on the Middle Fork, two on the Coast Fork, and one on the Long Tom River.

The average annual runoff of the Willamette Subregion amounts to about 38,200 cfs (27.6 million acre-feet). This flow is developed from twelve major tributaries. The eastern tributaries (Clackamas, Molalla, Santiam, Calapooia, McKenzie, and Middle Fork) drain 71 percent of the subregion and account for about 75 percent of the total yield of the Willamette system.

Surface-Water Hydrology

In general, the discharge pattern of the Willamette Subregion streams agrees very closely with the precipitation pattern. Maximum flows occur between the months of November and April--a direct result of runoff from precipitation and melting snow; minimum flows occur between July and October. In terms of volume, over 75 percent of the average annual yield occurs during the 6 wet months.

As a rule, the streamflow regimen of tributaries is similar to that of the main stem Willamette, with the exception that east tributaries (due to snowmelt, ground-water storage, and regulation) maintain higher sustained flows through the dry season than the tributaries draining the coastal mountains. Table 120 presents monthly discharge data for selected stations.

From the standpoint of waste discharge control, the low-flow months of July, August, September, and October are the most important. In most of the subregion, August is the critical month. The normal differences in magnitude between east-side and west-side tributaries become more pronounced during low flows; the average August flow of the five major eastern tributaries below the confluence of the Coast and Middle Forks amounts to about fifteen times that of the western tributaries. One-in-ten-year low flows are used to predict recurrence frequency of critical low flows. These data for selected stations are summarized in table 121.

Stream gradients influence water quality because they affect reaeration rates, time of travel, and bottom deposits. In the upland areas, the streams cascade through gorges and over rocks, providing a high reaeration rate and a short time of passage. In these reaches all but the heaviest solids are carried in suspension by the streams. In the lower reaches, flatter gradients result in low reaeration rates and extended travel times. Low velocities allow almost all settleable solids to fall out to form bottom deposits.

Table 120 - Average Monthly Discharge, Subregion 9 (12)

Location	Jan.	Feb.	March	April	May	June (CFS)	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
Sandy River near Bull Run, Ore.	3,280	3,192	3,072	3,357	2,979	1,973	843	505	501	1,186	2,851	3,890	2,302
Middle Fork Willamette River at Jasper, Ore.	6,391	3,160	3,363	3,055	3,498	4,697	1,965	2,235	2,121	3,521	6,732	6,241	3,916
Coast Fork Willamette River at Goshen, Ore.	3,188	2,837	2,329	1,533	884	613	421	882	195	526	1,713	3,020	1,512
McKenzie River near Coburg, Ore.	8,726	7,709	6,854	6,769	5,835	4,783	3,419	2,839	2,183	3,236	5,626	8,122	5,508
Long Tom River at Monroe, Ore.	2,261	1,533	815	431	215	85	50	50	1,137	176	705	1,776	770
Marys River near Philomath, Ore.	1,095	1,086	839	444	210	96	37	18	16	80	423	949	441
Calapooia River at Holley, Ore.	913	873	810	538	310	178	67	34	32	144	490	861	438
Willamette River at Albany, Ore.	27,029	21,007	17,842	14,441	11,69[illegible]	10,576	5,513	5,486	6,667	7,733	16,897	25,549	14,111
North Santiam River at Niagara, Ore.	2,810	1,561	1,508	1,723	2,352	2,112	1,387	1,189	1,281	2,244	3,876	3,181	2,102
South Fork Santiam River at Waterloo, Ore.	4,961	3,487	3,239	2,931	2,556	1,781	773	703	868	2,347	5,197	5,425	2,856
Santiam River at Jefferson, Ore.	12,992	9,909	9,224	8,282	7,339	5,149	2,279	1,740	2,326	5,681	12,404	13,864	7,596
Luckiamute River at Suver, Ore.	2,192	2,136	1,478	956	455	197	78	42	48	224	998	2,030	903
Willamette River at Salem, Ore.	44,985	35,397	29,538	24,438	19,241	15,376	7,002	6,551	7,616	13,571	30,786	41,394	22,991
South Yamhill River near Whiteson, Ore.	3,866	3,764	2,969	1,741	725	281	105	48	60	337	1,740	3,698	1,611
Molalla River near Canby, Ore.	2,101	2,006	1,712	1,529	1,091	664	218	97	115	473	1,496	2,115	1,135
Pudding River at Aurora, Ore.	2,763	2,606	2,037	1,514	776	421	158	75	90	350	1,331	2,456	1,215
Tualatin River at West Linn, Ore.	3,776	3,755	2,752	1,657	651	274	94	32	42	172	1,093	3,024	1,443
Willamette River at Oregon City, Ore.	60,034	52,029	42,601	33,451	23,346	16,938	6,938	5,979	7,237	15,456	38,971	55,809	29,900
Clackamas River at Estacada, Ore.	3,710	3,610	3,368	3,693	3,694	2,571	1,264	913	875	1,372	2,929	4,093	2,674

Table 121 - One-in-Ten-Year Low Flows, Subregion 9 (12)

Stream and Location	One-in-Ten-Year Low Flow (cfs) 1/
Sandy River near Bull Run, Oregon	270
Middle Fork Willamette River at Jasper, Oregon	1,150
Coast Fork Willamette River near Goshen, Oregon	< 100
McKenzie River near Coburg, Oregon	1,700
Long Tom River at Monroe, Oregon	40
Marys River near Philomath, Oregon	8
Calapooia River at Holley, Oregon	13
Willamette River at Albany, Oregon	2,300
North Santiam River at Niagara, Oregon	820
South Santiam River at Waterloo, Oregon	560
Santiam River at Jefferson, Oregon	1,400
Luckiamute River near Suver, Oregon	25
Willamette River at Salem, Oregon	5,200
South Yamhill River near Whiteson, Oregon	27
Molalla River near Canby, Oregon	54
Pudding River at Aurora, Oregon	47
Tualatin River at West Linn, Oregon	< 10
Willamette River at Oregon City, Oregon	4,050
Clackamas River at Estacada, Oregon	700

1/ Period of 1 month.

The most serious problems associated with low-flow conditions occur in the lower Willamette River (Portland Harbor) and in the Tualatin River.

Impoundments and Stream Regulation

At the present, there are 19 major impoundments in the Willamette Subregion. The storage in these impoundments has been allocated for the purposes of flood control, power, irrigation, navigation, water supply, and recreation. Although no storage is authorized for water quality, there are some incidental benefits derived from a result of operation of these reservoirs for the several other uses. At all Federal reservoirs now being designed or to be designed in the future, provisions are being made to study the inclusion of a selective withdrawal of water from various reservoir levels, to insure outflow temperatures are maintained at desirable levels. Reservoirs are operated with specified maximum and minimum rates of filling and evacuation.

The operation of Federal reservoirs in the region follows a seasonal rule curve as follows: During the major flood season,

November through January, the reservoirs are held at minimum pool to allow room for the storage of flood runoff; as the flood threat diminishes the reservoirs are gradually filled to full pool around the first of May. This point, full or conservation pool, is maintained throughout the summer or until the stored water is needed to meet downstream conservation demands. A minimum flow of 6,500 cfs is maintained at Salem during this period, and reservoir releases are usually required to meet this minimum during the latter part of the summer. After the summer season passes and as the flood potential increases, the water remaining in the reservoir is gradually evacuated. There is little or no conflict among water uses incorporated in this system of operation. The past several years it has been possible, through operation of the Willamette reservoirs, to provide flows higher than the specified minimums to assist in the improvement of water quality through the Willamette Basin and especially in the Portland Harbor, where dissolved oxygen becomes critical in the summer months.

The operation maintained in the summer of 1967 is a good example of the type of benefits that can be obtained through proper reservoir regulation. In 1967, many tributary streams of the Willamette dried up completely; streams with upstream regulation, however, were maintained throughout the period by storage releases from the Corps projects in the Willamette Basin, and flows and dissolved oxygen were kept at an acceptable level.

The effect of impoundments on water quality in the Willamette Subregion is not considered to be a major problem at present. Willamette dams are relatively new, and changes that may be occurring are still slight enough that they are difficult to detect. However, the Hills Creek, Lookout Point, Dexter, and Fall Creek Reservoirs have had some effects on water quality on the Middle Fork. Turbidity problems exist in the first three reservoirs, with excessive algal growths constituting the major source of turbidity in Lookout Point and Dexter. During 1966, releases from Fall Creek Reservoir caused a fish kill, apparently as a result of low dissolved oxygen and the presence of hydrogen sulfide in the released water. The Fern Ridge Reservoir on the Long Tom River suffers from prolific algal production and sediments which are kept in suspension by agitation from wind, boats, and bottom-feeding fish. Fisheries biologists have indicated that water in Detroit and Big Cliff Reservoirs is somewhat colder than desirable for optimum fish development.

Ground-Water Characteristics

Large supplies of ground water are available in the Willamette Subregion, generally in the lowland areas where development and need for water are most extensive. The major ground-water reservoirs are the alluvial deposits making up the flood plains and terraces along the Willamette River and major tributaries draining the Cascades. The permeable volcanic formations making up the higher Cascades provide good ground-water reservoirs, but the basalts and rhyolite soils of the western Cascades and the fine-grained sedimentary rocks of the Coast Range have a relatively low permeability and make poor aquifers.

The highly permeable gravels which underlie the flood plains of the Willamette and larger tributaries provide yields of 1,000 gallons per minute to individual wells without excessive drawdown. The lava aquifers and the sand and gravel deposits that underlie terraces have much smaller yields; but because they are more extensive, the aggregate withdrawal is greater than that from the flood plain gravels. Those wells located on the unconsolidated sediments and formations of the Coast Range are generally of low yield and have excessive drawdown.

The ground-water reservoirs are an important factor in sustaining streamflow, especially during the summer and fall. The very porous lava along the crest of the Cascade Range absorb a large quantity of spring and winter runoff, which appears in the form of springs at lower elevations. These ground-water releases provide a large portion of summer flows of streams originating in the Cascades.

The chemical quality of most ground water in the subregion is good; the waters are usually adequate for domestic, industrial, and irrigation use. Generally, the dissolved solids are less than 300 mg/l, and rarely do they exceed 500 mg/l. The water may be soft to hard, and silica generally ranges from 20 to 60 mg/l. Troublesome trace constituents are absent in most aquifers. However, hardness, salinity, and iron are above desirable levels in several locations. Iron is the most common constituent exceeding recommended levels. Brackish and saline waters are encountered at depth in the marine sedimentary strata on the slope of the Coast Range, and at some places saline water has migrated into overlying or adjacent aquifers. Bacterial contamination of aquifers is not common in urbanized areas, although some supplies have been rendered unfit for human use.

A more detailed discussion of ground water in the Willamette Subregion is presented in Appendix V.

Pollution Sources

The municipal and industrial wastes in population equivalents are summarized in table 122. The table generally represents waste loadings during the critical summer low-flow period.

Table 122 - Summary of Municipal and Industrial Waste Treatment, Subregion 9, 1965 (10)

	Municipal					Industrial				
	Secondary	Primary 1/	Lagoons	Other	Total	Pulp and Paper 3/	Wood & Lumber Products	Food Products 5/	Misc.	Total
Upper Willamette Subbasin										
Number of Facilities	6	3	1	3	13	1	7	2	0	10
Population Served	73,250	9,300	900	700	84,150					
PE Untreated	244,500	15,300	900	700	261,400	112,000	6,300	300		118,600
PE Treated	80,710	8,060	160	550	89,480	12,000	3,080	150		15,230
% Removal Efficiency	67	48	83	22	66	90	52	50		887
Middle Willamette Subbasin										
Number of Facilities	28	3	7	6	44	6	13	9	4	32
Population Served	128,535	21,300	4,490	1,150	155,475					
PE Untreated	567,230	116,050	4,510	1,150	688,940	2,340,400	16,650	131,500	30,850	2,519,400
PE Treated	85,120	82,820	780	500	169,220	561,760	6,610	2,680	21,090	592,140
% Removal Efficiency	85	29	83	57	76	76	61	98	32	76
Lower Willamette Subbasin 2/										
Number of Facilities	32	2	0	0	34	2	0	2	1	5
Population Served	121,340	5,750			127,090					
PE Untreated	214,990	9,600			224,590	2,039,000		2,750	8,000	2,049,750
PE Treated	63,720	6,000			69,720	500,300		1,270	8,000	509,570
% Removal Efficiency	71	38			69	76		54	0	75
Total										
Number of Facility	66	8	8	9	91	9	20	13	5	47
Population Served	323,125	36,350	5,390	1,850	366,715					
PE Untreated	1,026,720	140,950	5,410	1,850	1,174,930	4,491,400	22,950	134,550	38,850 6/	4,687,750
PE Treated	229,550	96,880	940	1,050	328,420	1,074,060	9,690	4,100	29,090 6/	1,116,940
% Removal Efficiency	78	32	83	43	72	76 4/	58	97	25	76

1/ Under orders for improvement to secondary.

2/ Excludes Portland which discharges to the Columbia River.

3/ Includes two particle-board plants, but excludes one plant discharging to the Columbia and one building board and papermill.

4/ Refers only to summer period and reflects temporary withholding by lagoon storage, land application and barging.

5/ Excludes wastes treated by municipal plants.

6/ Includes numerous small discharges to Portland Harbor.

Municipalities and industries produce wastes equivalent to those from a population of approximately 5.9 million persons. Of this total, 77 percent is generated by the pulp and paper industry, 2 percent by the food-processing industry, and 20 percent by municipalities. The remaining 1 percent is from other miscellaneous industries within the subregion and uncontrolled discharges to Portland Harbor through private and storm sewers.

Waste treatment and other means of waste reduction decrease the normal waste load to the subregion's waters by about 76 percent, so that 1.45 million PE actually reach surface waters.

Other significant sources of pollution in the subregion include wastes from the rural-domestic population, irrigation, livestock and poultry, land use and recreation, navigation and dredging. Land use is probably the most important of these, since it contributes heavily to sediment problems.

Municipalities

Upper Willamette Subbasin An average reduction in biochemical oxygen demand of about 67 percent is accomplished by municipal waste treatment facilities in the Upper Willamette Subbasin. Of the 13 municipal waste sources, six communities have less than secondary treatment.

The Eugene-Springfield Service Area accounts for about 31,000 PE of the total municipal waste load of 89,480 PE in the subbasin. The City of Eugene, whose wastes are seasonally increased by about 250,000 population equivalents by industrial discharges, is the largest waste source. The city is currently expanding its treatment capacity to better handle these waste loadings. Also within the service area, Springfield, Harrisburg, and Junction City provide secondary treatment facilities.

A satisfactory level of municipal waste treatment is accomplished outside the Eugene-Springfield Service Area. All cities, with the exception of Westfir which relies upon septic tanks for disposal of wastes, have municipal waste treatment facilities.

Middle Willamette Subbasin In general, municipal waste treatment practices in the Middle Willamette Subbasin are excellent. An average reduction in organic oxygen-demanding wastes of about 76 percent is accomplished by the municipal facilities. Of the 44 municipal systems, 28 presently provide secondary treatment; however, at least four of these facilities require enlargement or additions. Seven communities provide satisfactory treatment with oxidation lagoons. In addition, one small municipal system utilizes septic tank disposal. Municipal waste sources in the subbasin are concentrated in the Albany-Corvallis and Salem Service Areas.

All communities in the Albany-Corvallis Service Area provide secondary waste treatment. However, the Albany plant has only a partial secondary treatment plant, operating a trickling filter but lacking a secondary clarifier. The municipal facilities at Albany and Corvallis receive waste discharges from food-processing industries. As a result, these facilities discharge 48,000 and 30,700 PE, respectively, to the Willamette River during August and September. The cities of Sweet Home, Philomath, and Lebanon are the other major waste sources in the service area discharging 320, 480, and 1,600 PE respectively.

In the Salem Service Area the City of Salem is the principal waste source, releasing an organic loading of about 26,000 PE to the Willamette River. Salem's secondary treatment facility serves a municipal population of over 70,000 persons and receives industrial wastes from food-processing industries equivalent to those from another 400,000 persons. The City of Dallas is also a significant waste source, discharging about 3,100 PE from its secondary treatment plant to small Rickreall Creek. Other municipal waste sources in the service area are the cities of Independence and Monmouth.

Outside the two major service areas, waste treatment practices are also generally excellent. The cities of McMinnville and Silverton are the largest waste sources, releasing about 1,500 and 2,800 PE, respectively. All other municipalities discharge an organic loading of less than 800 PE and usually less than 300 PE. The only treatment deficiencies are at Sheridan and Canby. The Oregon Department of Environmental Quality (DEQ) requires that Sheridan add a secondary clarifier to its facilities, and that Canby enlarge its present plant.

Lower Willamette Subbasin Municipal waste treatment practices in the Lower Willamette Subbasin are generally good. Only two communities have less than secondary treatment. The normal waste loading to subregion waters is only about 28,000 PE; however, several facilities also treat industrial wastes from food-processing industries. As a result, seasonal loadings can be greatly increased. The City of Portland and community of Gresham discharge waste loadings of 260,000 and 3,000 PE, respectively, to waters outside the Willamette Subregion.

Despite the fact that the Willamette River flows through the center of Portland, municipal waste loads to the river are comparatively minor. Effluents from adequate secondary treatment plants serving six communities between Milwaukie and West Linn contribute a waste load of about 10,000 PE to the lower Willamette. No particular problems have been created by these discharges, except that detergent foam has detracted from the aesthetic appearance of the Willamette River below the Oregon City treatment

plant outfall. Most of the municipal wastes of Portland are treated in a primary plant which discharges to the Columbia River, where they have no effect on the quality of Portland Harbor. However, numerous discharges from private and storm sewers estimated to have a total strength of about 8,000 PE, flow directly into the harbor. The City of Portland is currently constructing an interceptor sewer to collect these wastes.

Since the area is nearly all urbanized, runoff through storm sewers carries significant quantities of sand, gravel, soil, toxic garden chemicals, oils, animal wastes, and other organic litter. Most of the storm sewer flow occurs during high river flows, and adverse quality effects are not readily apparent.

An excellent level of waste treatment is maintained in the Tualatin River drainage, with all communities operating secondary waste treatment plants. A normal waste loading of about 13,000 PE is released by the municipal facilities. However, several facilities also receive wastes from food-processing industries, resulting in an organic loading of another 30,000 PE during the peak canning period which occurs during the critical low flow period. Even though a high level of treatment is accomplished, serious water quality management problems exist in the Tualatin Basin. Rapid suburban population growth and a multiplicity of governmental entities with responsibility for waste treatment tend to complicate an already difficult problem.

An additional source of sanitary wastes in the lower Willamette is the houseboats which anchor along the Willamette from Oregon City to the mouth, and which provide no waste treatment. The DEQ requires that these houseboats provide an adequate method of waste treatment. A similar area of concern is the sanitary wastes discharged by commercial oceangoing vessels in Portland Harbor.

Industries

Upper Willamette Subbasin Industrial waste production in the Upper Willamette Subbasin is comparatively small. The major industrial waste sources are the pulp and paper, forest products, and food-processing industries. In general, a high level of waste reduction is provided by the pulp and paper and forest products plants. The food-processing industry usually discharges its waste waters to municipal systems for treatment.

The principal waste source of the area is a pulp and papermill at Springfield. The mill, whose waste treatment practices are exemplary, employs the sulfate pulping process, recycling of process waters, primary and secondary waste treatment, and

summer spray irrigation with waste waters to minimize effects on the quality of the river. The mill's treatment system achieved over a 90 percent reduction in organic oxygen demand, resulting in an effluent strength of about 12,000 PE.

Numerous sawmills and plywood mills are scattered throughout the Upper Willamette Subbasin. These mills tend to be large, efficient installations whose waste wood provides the raw material for pulp and papermills. The waste treatment practices of these sawmills and plywood mills have received little attention until recently. However, solids from such industrial plants can be a potential source of aesthetic damages, and of materials which can serve as a base for attachment of Sphaerotilus. The EPA, WQO Water Laboratory has completed a study of waste disposal methods for glue wastes from sawmill and plywood operations and is currently studying the effects of log storage and handling practices on water quality. The DEQ plans to use the results of these studies to recommend additional waste treatment requirements.

Visual evidence of pollution from sand and gravel operations has been reported in the Willamette River between the confluence of the Middle and Coast Forks and Eugene. Waste control measures to reduce the problem have been initiated.

The food-processing industry is mainly centered in the Eugene-Springfield Service Area. Effluents are generally discharged to municipal waste treatment systems. Several dairies and food-processing plants discharge to the Eugene secondary treatment plant. The Eugene fruit growers discharge to the Junction City secondary treatment plant.

Middle Willamette Subbasin Industrial waste production in the Middle Willamette Subbasin constitutes over one-half of the total oxygen-demanding strength of all wastes discharged to waters of the Willamette Subregion during August and September. The principal sources are the manufacture of pulp and paper and the processing of foodstuff. The annual average industrial organic waste load produced in the subbasin is estimated to total about 2.5 million PE, which are reduced to about 0.6 million PE by waste treatment.

The major waste sources in the subbasin are four pulp and papermills. Three of these--at Lebanon on the South Santiam, and at Salem and Newberg on the Willamette--are sulfite process pulp mills, with a very high waste-to-product ratio. The Albany mill is a sulfate process mill, distinguished by the lower waste-to-product ratio that is obtained in sulfate pulping. As a group, these four mills account for over 70 percent of the total organic waste production of the subbasin and for over 90 percent of the average waste discharge during the summer months.

An ammonia-base sulfite mill at Lebanon discharges wastes estimated at 56,400 PE daily into minimum river flows of less than 100 cfs. Present waste reduction measures, in addition to process controls, consist of sedimentation basins and aerated lagoons and discharge into Mark's Slough about 1 mile from the South Santiam River. During summer months, the slough discharges through a bed of river-run rock, which creates an impoundment and acts somewhat like a trickling filter. In addition, some strong waste liquors are concentrated by evaporation and then either burned or dried for by-product recovery.

A pulp mill in Albany discharges about 63,200 PE of pulp mill wastes daily to the Willamette River. Two earthen ponds provide primary settling with 24-hour detention of the wastes before discharge. An interim method of further treatment has been accomplished with seepage pits, with full secondary treatment required by the DEQ by July 1972.

A calcium-base sulfite pulp and papermill at Salem discharges large waste loads to the Willamette River most of the year. The mill operates primary settling facilities which normally discharge about 28,000 PE. During the summer season these wastes are temporarily held in two lagoons with a combined capacity of 180 mg. The mill has orders from the DEQ to install chemical recovery systems and secondary treatment or equivalent control by July 1972.

A paper company at Newberg, which produces unbleached sheet pulp, also relies upon year-round primary sedimentation and temporary storage lagoons for waste reduction during the summer low-flow periods. Raw waste production of about 774,000 PE resulting from pulping operations is reduced to about 130,000 PE by diverting strong liquor to storage lagoons in the summer. The mill has orders from the DEQ to install chemical recovery and secondary treatment or equivalent control of total mill wastes by July 1972.

Experience with storage of pulp mill wastes has indicated that it is an inappropriate method to be relied upon for a long-term solution to the problem of waste reduction. In theory, it provides for a fuller utilization of the assimilative capacity of the stream by gearing waste discharges to flows. Problems occur, however, during prolonged dry periods, which result in complete filling of waste holding ponds and subsequent overflow, or the necessity for plant shutdowns. Loss of holding capacity as a result of accident can result in devastating loads of concentrated wastes.

The food-processing industry of the Middle Willamette Subbasin has done an excellent job of reducing its wastes. Large

plants at Stayton, on the North Santiam River, and at Woodburn, on a tributary of the Pudding, practice land disposal of their wastes, greatly reducing their discharge to watercourses. At Corvallis, Albany, Salem, McMinnville, and Silverton, food-processing wastes are treated in the municipal waste treatment plants. The Salem waste treatment plant is an example of municipal and industrial cooperation in the interest of pollution abatement.

A lumber company at Corvallis is the largest lumber and wood products waste source in the subbasin. The hardboard plant utilizes primary settling ponds and aerated ponds for treatment of wastes. The effluent from the facility has an organic oxygen-demanding load of about 15,000 PE. Several sawmills and plywood mills also contribute minor waste loadings to waters.

Two metallurgical companies at Albany are engaged in limited reduction and extensive fabrication of exotic metals. The firms have been a source of toxic inorganic wastes to the small streams to which they discharge and to the Willamette River. However, both firms are now completing plans that should eliminate the problem.

Lower Willamette Subbasin Industrial wastes produced in the Lower Willamette Subbasin constitute about 45 percent of the total oxygen-demanding strength of all wastes discharged to the Willamette River system. The total estimated industrial organic waste produced in the Lower Willamette is about 2.1 million PE, which are reduced during the critical period to about 0.5 million PE by waste treatment or other means of waste reduction. The pulp and paper, food-processing, and wood products industries are the most significant from a waste standpoint, but the chemical, metal fabrication, and electronics industries contribute inorganic waste materials.

The principal waste sources of the area are the pulp and papermills at West Linn, a paper company at Oregon City, and a gypsum company and a pulp and papermill at St. Helens. These mills account for over 75 percent of the total industrial waste discharge in the subbasin.

The paper company at Oregon City operates a sulfite papermill and a refiner and stone groundwood mill producing paper products. A conversion program changing the sulfite process to magnefite is complete. A substantial decrease in wastes has resulted from this conversion and chemical recovery. The mill has also constructed primary sedimentation facilities. Total wastes generated at the plant currently amount to about 882,000 PE per day. This load is reduced to 172,700 PE during the low-flow

period by barging strong wastes to the Columbia River. This practice is considered to be an interim measure by regulatory authorities and is acceptable only until 1970.

One pulp and papermill at West Linn produces paper products from a stone refiner groundwood pulp mill. Mill effluent is diverted to a primary settling tank and a holding lagoon. About one-half of the volumetric flow carrying about two-thirds of the settleable solids is diverted to the primary settling tank for solids separation. A 75 mg temporary holding lagoon receives the strong wastes during the low-flow season, resulting in a discharge of about 120,000 PE.

The gypsum company at St. Helens operates a groundwood pulp mill which produces one-half-inch soft-board. Primary and secondary clarifiers and an aerated lagoon have been installed and reduce the effluent strength to about 12,000 PE.

The other corporation at St. Helens is currently in the process of expanding its bleached kraft pulp and papermill. Evaporation and burning of concentrated waste liquors for recovery of base material are practiced, and the mill has a primary sedimentation facility. The mill and the DEQ have agreed that the total BOD loading from the plant to Multnomah Channel should not exceed the pre-expansion load of 156,000 PE. If the company cannot meet this requirement after expansion, or if the load to the channel depresses the oxygen below the standard established for the water body, then additional treatment or an extension of an outfall to the Columbia River may be required.

The food-processing industries in the Lower Willamette Subbasin have done an excellent job of reducing wastes. The firms generally use land irrigation or discharge to municipal waste treatment systems. As a result, only minor waste loadings actually reach waterways. The most important area of waste discharge is the Tualatin Valley, where seasonal food-processing wastes are discharged to municipal systems.

The only major wood products industry in the Lower Willamette Subbasin is at Forest Grove. The plant practices primary settling and land disposal of wastes during the low-flow months. The DEQ has required that no discharge shall be allowed during summer months beginning in 1970.

Other industries which are smaller in size contribute some organic matter and are potential sources of toxicants, oil, grain cleanings, and other deleterious materials. These industries are concentrated in the Portland Harbor area. In general, the DEQ requires that these industries provide some type of waste treatment and/or connect to the city sewer.

Rural-Domestic

Approximately 602,200 persons, or 45 percent of the sub-region population, are served by individual waste disposal systems. In general, septic tanks and some type of subsurface disposal are used by the rural population. The actual waste load reaching waterways is not considered to be large.

Irrigation

Effects of irrigation on water quality within the Willamette Basin are minimal. The most obvious potential for stream pollution from irrigation is from return flow, but about 95 percent of water application on the 244,000 acres of irrigated land is by sprinkler with virtually no surface runoff. Application is regulated to economically control pumping costs and to obtain optimum productivity with but little excess water applied. Most chemicals applied are utilized by the crops or bound in the soil. Runoff from fall and winter rains does carry some natural and applied minerals and chemicals to the rivers; however, streamflow during these periods is generally great enough to preclude development of problems.

Annual diversion of water from surface sources and pumpage from ground-water sources were about 569,000 acre-feet in 1966. The flow of some streams is nearly depleted during periods requiring irrigation; thus, the quantity and quality of the remaining flow are insufficient to prevent degradation caused by the addition of any pollutants. Return flow does not replenish streamflow during the same period but may cause early fall rains to run off more rapidly since shallow aquifers are more nearly saturated from irrigation.

Present regulations and recommended practices give full cognizance to programs of water pollution control. Research efforts have resulted in guidelines for water and chemical application to produce optimum economic returns and minimize water pollution.

Agricultural Animals

Readily defined adverse effects of agricultural animals on water quality, even with nearly 1/4 million head of livestock, have been limited to minor instances of localized pollution. Problems of bacterial contamination and organic pollution have usually been traced to improper discharge of liquid and solid wastes from large poultry houses or drainages from dairies and

feed yards. Droppings and manure are frequently collected, stored, and applied to the ground in liquid form or treated in oxidation ponds.

Animal wastes flushed into Willamette streams not only contribute a high bacterial load to the streams but also exert a biochemical oxygen demand. Estimates of potential fecal streptococci from animal sources in the Willamette Basin for 1959 were over 78 times those from human sources. Assuming a 95 percent reduction by land disposal, the magnitude of the residual load from animal sources is almost eight times that from human sources before treatment.

The oxygen demand of the wastes from the 223,000 head of livestock in the basin would be about equal to that of the wastes from the total population. What amount of these wastes reaches the waterways is unknown. However, these relationships point out the necessity of proper handling and management of domestic animal wastes to prevent them from reaching the streams.

Present regulation in terms of laws is adequate, but obtaining full and continuous compliance is a problem. Research activities include attempts to develop adequate waste treatment techniques that are also economical for use by the agricultural industry.

Other Land Use

Land-use practices can substantially alter the physical environment of a river basin and affect water quality. The production and transport of sediment are the most significant quality impairment resulting from land use in the Willamette Basin. High concentrations of sediment generally occur during periods of high precipitation or snowmelt and are carried in flood flows.

The lands most subject to erosion are forest lands on steeper slopes which are exposed to high rainfall and snowmelt. These lands comprise 66 percent of the basin, and some of the soils are of geologic origin susceptible to erosion. Therefore, it is imperative that proper management practices be followed when making changes in the forest environment.

The major single source of sediment is bank-cutting caused by flood flows both in descent from the steeper forest slopes and in stream and river channels of the valley floor. Land-management practices have not controlled this type of erosion nor have present flood control techniques and channel protection projects.

Stripping of vegetative cover and massive disturbance of soil in construction activities for urban-suburban structures and highways contribute large quantities of sediment during runoff periods.

Most of the substances that are toxic to the aquatic habitat are man-made or caused. These include organic and inorganic pesticides, certain minerals, and petroleum products washed into streams from highways or industrial areas. None of these toxicants resulting from land use is considered to be a major problem in the Willamette Basin.

The use of pesticides on agricultural and forest land is extensive in the Willamette Basin, with 1,600 tons of herbicides, 8,000 tons of fungicides, and 3,300 tons of insecticides applied annually. Careful use, combined with the ability of the soil to act as a filter, has generally prevented damaging concentrations from reaching the waterways. A hazard is present, however, when toxicants are handled by individuals without proper training. Regulation of the use of pesticides should, therefore, be continued by control agencies.

The logging practice of clear-cutting small scattered tracts will cause temporary increases of 1° to 8°F. (-.6° to 4.4°C.) in stream temperatures of local watersheds until sufficient vegetative cover is restored to provide stream shade. However, these increases have had little effect on temperatures of major streams in the basin, and no identifiable problems have resulted.

Organic litter and debris are carried to the streams from areas in forest and farmland that have been recently disturbed. Some of this material floats and creates unsightly conditions while some settles and forms troublesome sludge beds. None of these aspects have been identified as a cause of specific problems now, but they contribute to water quality degradation and mechanically affect fish passage. The effects of log ponding and handling on water quality need further study and definition. Log ponds are a source of suspended material and complex organic compounds which may generate undesirable color and odor.

Recreation

The Willamette River and all of its tributaries are a part of the present recreational resources of the basin. Recreation of one type or another is continuous at some locations in the mountains ringing the basin to the mouth of the river. Developed and organized recreational installations have sanitary facilities designed to protect the public and the adjacent waters. Pit privies or central facilities discharging to septic tanks and tile fields

are the most common means of waste disposal. Increased usage of a park area is frequently followed by construction of improved sanitary facilities.

Sanitary waste facilities are usually deficient at improvised recreation sites such as many small boat landings, water skiing areas, and in pleasure boats and houseboats. The load, organic and bacterial, from these sources has not been identified numerically, but its importance has been recognized.

Regulations governing installation of sanitary facilities are generally adequate, but are difficult to enforce because of the many improvised recreation sites. Some principal research activities are oriented towards improvement of disposal facilities for small recreation areas, pleasure craft, and houseboats.

Navigation and Dredging

Dredging operations have little effect on water quality in the Willamette Subregion except in Portland Harbor.

Accidental spills and bilge pumping are significant pollutional sources, as evidenced by a serious oil spill in the Portland Harbor in February 1968. Continuous dredging of sand, silt, and sludge beds is required in the lower Willamette River to facilitate navigation. The dredged materials are utilized in the Portland industrial area for landfill; consequently, pollution problems are limited to the immediate area of the disturbed sludge beds.

The river is intensively used for transporting logs in rafts to mills. The pollutional effects of this practice cannot be fully quantified but are not considered to be great.

Present Water Quality

Water quality is both a measure of the usefulness of a stream and a consequence of the nature and degree of existing use. The critical period of water quality in the Willamette occurs during the summer months, when waste production is high and streamflows are low; this period has, therefore, been used to described present quality.

The following discussion is based on data from the DEQ, joint sanitary surveys by the FWQA and DEQ, and from FWQA monitoring stations in the Portland Harbor and at Oregon City.

Main Stem Willamette River

The Willamette River from its headwaters to Salem is a relatively shallow and fast-moving stream. Dissolved oxygen concentrations throughout this stretch are near saturation, ranging from 8 to 9 mg/l during the summer months. Below Salem, and particularly from Newberg at milepoint 50 to the mouth, the channel deepens, and dissolved oxygen levels diminish. A profile of minimum summer dissolved oxygen levels through this reach of the river shows progressive degradation from Salem to the mouth (figure 92.)

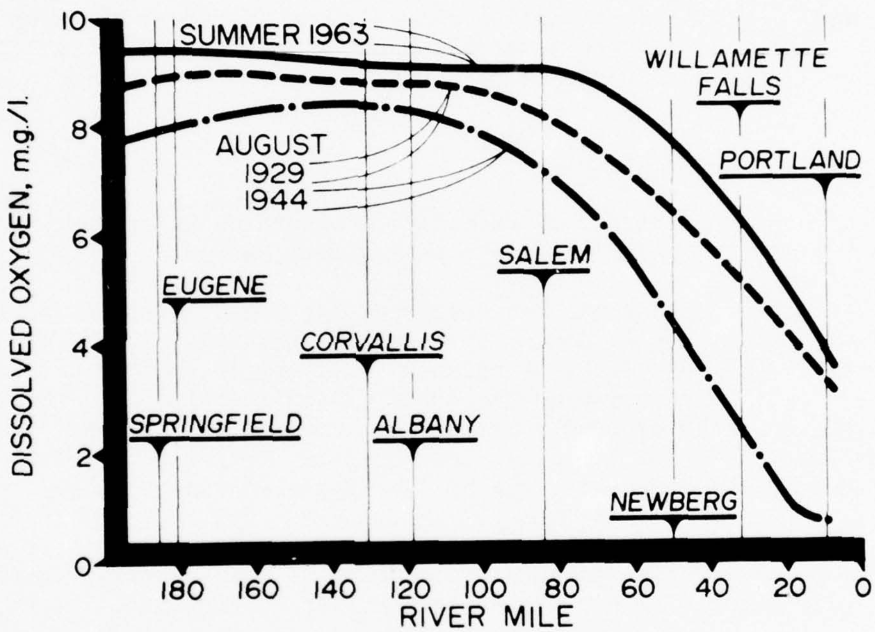


FIGURE 92. Dissolved Oxygen Profile (Generalized), Willamette River

The most critical oxygen levels occur in the Portland Harbor, where average summer concentrations range from 3 to 4 mg/l with historical minimum daily readings of less than 2 mg/l. The harbor has a long history of low dissolved oxygen during the months of July, August, and September. This condition also persists through Multnomah Channel (figure 93).

In the summer of 1967, one of the lowest years of record, dissolved oxygen concentrations in Portland Harbor were well below the five mg/l objective established for passage of salmonid fish

species through the harbor. Since 1967, regulation has improved and these conditions have not reoccurred.

The Willamette River above Harrisburg is characterized by relatively low temperatures, with maximum values below 70°F. (21°C.) and average values from 56°F. to 65°F. (13° to 18°C.) during the summer months.

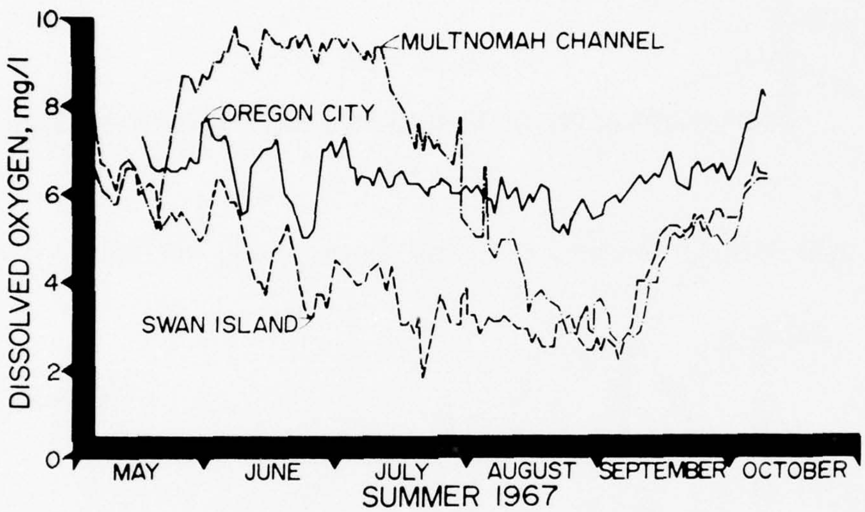


FIGURE 93. Dissolved Oxygen Profile--Summer 1967, Willamette River

Below Harrisburg, temperatures do not always meet fishery requirements, due to solar radiation on the exposed river. The relationship of temperature in Portland Harbor to flows during summer months is shown in figure 94. Maximum temperatures exceed 70°F. (21°C.) and averages range from 68°F. to 71°F. (20° to 22°C.)

Figure 95 presents a bacteriological profile of the Willamette River. The bacteriological quality of the main stem Willamette below Springfield is highly variable but generally unsuitable for water-contact recreation. Total coliform densities throughout the main stem range from 1,000 to 50,000 MPN (most probable number of coliform bacteria per 100 ml), with occasional maximums as high as 70,000 MPN. Most levels are considerably above the bacteriological limit of 1,000 MPN for water-contact recreation.

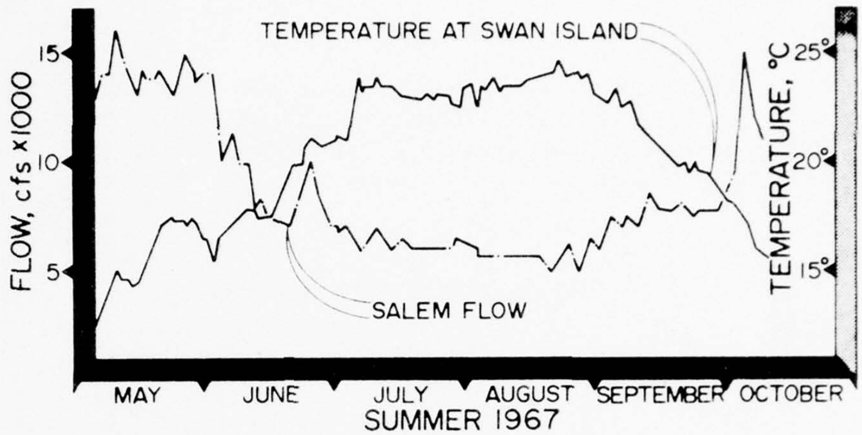


FIGURE 94. Temperature and Flow--Summer 1967, Willamette River

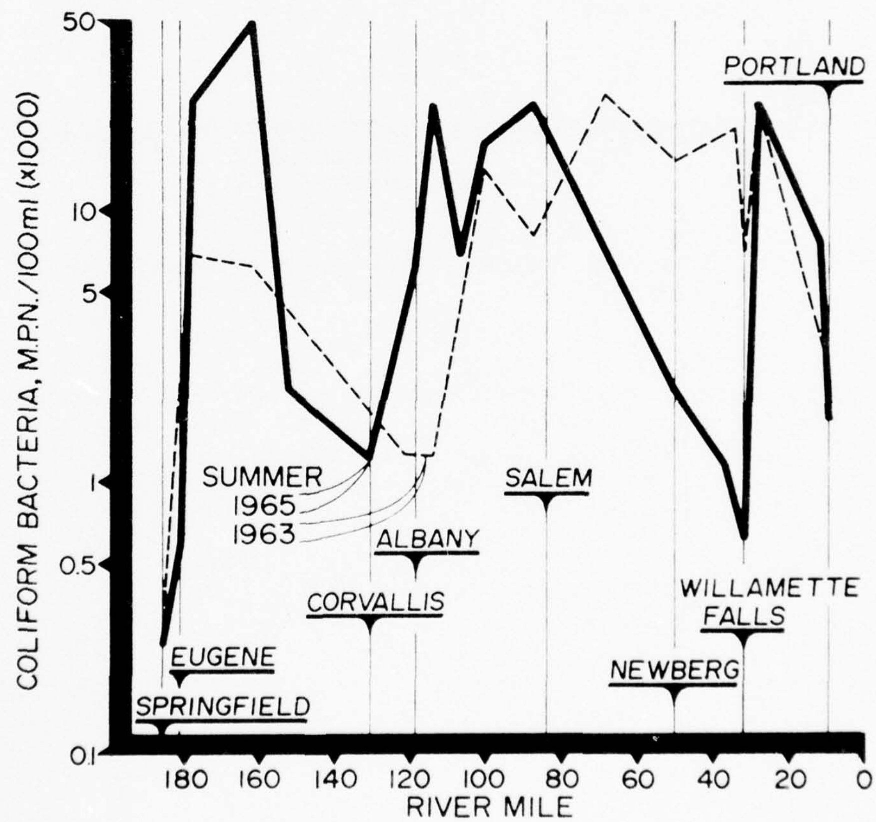


FIGURE 95. Coliform Bacteria Profile, Willamette River

It should be noted that the main peaks occur below major service areas where substantial municipal wastes have been discharged. An improvement in bacteriological quality below Salem between 1963 and 1965 reflects the completion of secondary waste treatment facilities with improved interception of wastes. However, the 1965 profile indicates that bacterial levels are at present unsatisfactory for water-contact recreation in almost the entire main stem Willamette.

A recent cooperative survey by the DEQ and FWQA showed the sulfite pulp and paper operations produce inordinately high total and fecal coliform counts.

The mineral quality of the main stem Willamette is uniformly good and, even under the most stringent criteria, suitable for all uses. The surface waters of the Willamette Subregion are a calcium-magnesium bicarbonate type, with these ions making up about 70 percent of the total dissolved ions. The dissolved solids content of the river ranges from less than 40 mg/l to a maximum of about 85 mg/l. Maximum concentrations of dissolved solids increase from Eugene to Portland, but are well within the Public Health Service drinking water standards. Hardness of the water is generally less than 30 mg/l.

Nitrogen and phosphorous levels are well below the maximum levels listed in the drinking water standards. Phosphorous concentrations remain well below 0.01 mg/l. However, there are enough of these nutrients to promote the needed growth of algae.

Surface waters are suitable for most industries. Industries that require waters of low silica content would have to use treatment because silica concentrations are generally in excess of 10 mg/l. For some industrial uses, treatment would be required for color and turbidity.

Sediment transport and suspended organic matter such as fiber from pulp mills create periodic water quality problems in several parts of the Willamette Basin. In periods of low discharge, the river carries almost no suspended matter; however, sediment concentrations increase in most tributaries and in the main stem in times of high runoff. About 80 percent of the annual sediment discharge usually occurs during the high precipitation and runoff period (November to February). Sediment discharge is less uniformly distributed, with respect to both time and area, than streamflow. More sediment may be discharged by one flood than is discharged during several average years. For instance, during the period December 21-31,1964 the total sediment discharge of the Willamette River at Portland was 6.6 million tons, which is 1.5 times the sediment discharge of the entire 1963 water year. This is almost three times the annual

average discharge of 2.3 million tons. The highest sediment concentration observed in the Willamette River has been 2,050 mg/l at Portland.

Suspended organic matter such as fiber from pulp mills creates water quality problems in the Willamette. Such materials and other settleable solids from pulp and paper operations add to bottom sludge deposits and exert a considerable oxygen demand on the lower Willamette and Portland Harbor.

Biological slimes, including Sphaerotilus, create nuisance conditions for sport fishermen in the lower Willamette by fouling lines and destroying fish habitat. These growths are stimulated by the nutrients present in pulp and papermill effluents.

Toxic elements and compounds are not normally found in the Willamette River. Accidental spills and errors in application of sprays and chemicals do, however, result in infrequent and localized pollution and fish kills. Runoff of oil from streets, parking lots, and garages has not given rise to critical problems. Oil spills in the Portland Harbor have been detected, and violators prosecuted under the provisions of the Oil Pollution Act.

Tributaries

Most of the tributaries maintain dissolved oxygen levels of at least 80 percent saturation throughout the summer months, and adequately meet fishery objectives. Average summer dissolved oxygen concentrations, except for several problem areas, range from about 7 to 10 mg/l. The only tributary streams having a major depression in dissolved oxygen are the South Santiam and Tualatin Rivers and Rickreall Creek.

The South Santiam below Lebanon has experienced severe depressions in dissolved oxygen for many years, and does not meet dissolved oxygen objectives. Minimum levels during recent summers have ranged from four to less than one mg/l below a pulp mill near Lebanon.

Maximum temperatures of over 70°F. (21°C.), with peak temperatures in excess of 80°F. (27°C.), occur in the lower reaches of tributaries originating in the Coast Range. Major tributaries from the Cascades are characterized by lower temperatures, generally not exceeding 70°F. (21°C.).

The relatively deep reservoirs--like Detroit and Lookout Point--are thermally stratified during the summer with temperatures ranging from 70°F. (21°C.) at the surface to 45°F. (7°C.) at the reservoir bottom.

The bacteriological quality in the lower reaches of most tributary streams is unsatisfactory for swimming and other water-contact recreation. Only the Middle Fork, the McKenzie, and the Clackamas meet bacterial objectives throughout their lengths. The upper reaches of most tributaries--above major municipal waste sources--are of excellent bacteriological quality.

Mineral quality of Willamette tributaries is excellent and suitable for all uses. The waters are a calcium-magnesium bicarbonate type with these ions making up about 70 percent of the total dissolved ions. The dissolved solids content of most streams ranges from less than 40 mg/l to a maximum of about 85 mg/l. Some small streams on the valley plain that receive their base flows from terrace deposits, particularly the Willamette Silt, may contain dissolved solids in excess of 100 mg/l during low-flow periods. The major streams draining the Coast Range are slightly more mineralized than those draining the Cascade Range, but the chemical composition is the same.

Suspended sediment concentrations of large streams in the Willamette Subregion generally range from less than 10 mg/l to about 400 mg/l but can exceed 2,000 mg/l during major floods. Some concentrations of sediment measured in Willamette streams are shown in table 123.

Table 123 - Sediment Concentrations in Willamette Streams (as of 1959), Subregion 9 1/

Location	Concentration (ppm)
Coast Fork Willamette River near London (above dam)	400
Coast Fork Willamette River below Cottage Grove Dam	260
Row River near Star (above dam)	330
Row River below Dorena Dam	130
Willamette River at Springfield	350
McKenzie River	240
Marys River	500
Calapooia River	340
Santiam River	503
Luckiamute River	410
Willamette River at Salem	400
South Yamhill River	800
Tualatin River	390

1/ Elliott Flaxman, SCS, Proceedings, Fifth Symposium PNW, 1959, WSPC, USPHS.

Biological slimes, including Sphaerotilus, create nuisance conditions for sport fishermen in the McKenzie River by fouling lines and destroying fish habitat. These growths are stimulated by the nutrients present in pulp and papermill effluents.

Summary of Problems

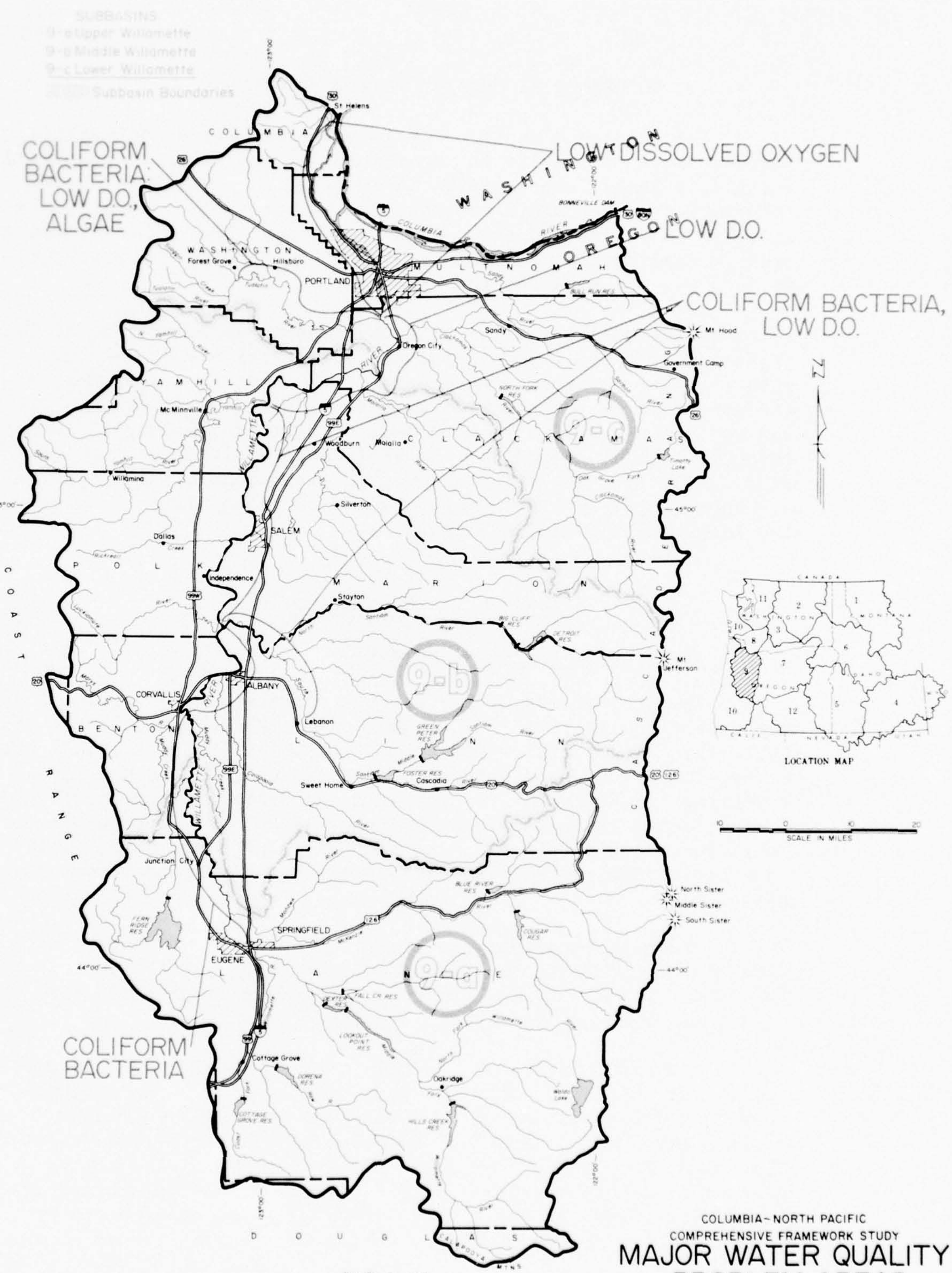
One of the most serious water pollution problems that exists in the Pacific Northwest occurs in the lower Willamette River. Under low-flow conditions, discharges of industrial wastes by pulp and papermills at Oregon City, Newberg, and West Linn result in dissolved oxygen depression. The affected portion of the river passes through the most densely populated part of Oregon and serves as the passageway for all migratory fish that spawn in the Willamette system.

Bacterial concentrations above acceptable levels for water-contract recreation exist in the Willamette River below Springfield. Also, there has been an increasing prevalence of Sphaerotilus and other slime-like growths throughout the Willamette River.

Periods of nearly complete oxygen depletion occur annually in the South Santiam River below Lebanon as a result of waste effluents from a Lebanon pulp and papermill and the municipal secondary treatment plant. The river is completely befouled, and use is restricted for recreation, fish, and water supply. Migration of anadromous fish is significantly hindered, and the resident summer fishery has been eliminated.

The Tualatin River receives more wastes during periods of low flow than can be assimilated by the meager amount of streamflow. The growth rate and flow diversions within the Tualatin area have resulted in poor water quality conditions in spite of a high degree of treatment of waste discharges. Periods of low dissolved oxygen, bacterial contamination, slime and algal blooms, and contamination by toxicants are nearly an annual occurrence. Uses of the river are restricted to those requiring only low-level quality water.

Generalized water quality problem areas are shown graphically in figure 96.



COLUMBIA-NORTH PACIFIC
COMPREHENSIVE FRAMEWORK STUDY

MAJOR WATER QUALITY PROBLEM AREAS

WILLAMETTE SUBREGION 9

1970

FIGURE 96

FUTURE WATER QUALITY MANAGEMENT NEEDS

The ensuing discussion of future needs in the Willamette Basin is based primarily on the results of the recently completed Willamette Basin Comprehensive Study (Type 2). While the basic information and economic projections used in that study differed somewhat in detail and scope from this study, the resulting water quality implications are compatible. As a result, a reanalysis of data was not made for this study.

Water quality in the Willamette Basin will continue to be primarily affected by municipal and industrial wastes. Future water quality management needs are determined, in large part, by the magnitude of such future waste production. Projections of raw waste production have been made by utilizing population and economic data developed for the Willamette Basin Comprehensive Study (Type 2). Subregion and service area population projections are shown in table 124. Municipal and rural population components are shown graphically in figure 97.

Future Waste Production

Municipal, Industrial, Rural-Domestic

The projections of raw waste production are given in population equivalents (PE) for the years 1980, 2000, and 2020 in table 125. Industrial waste production is estimated for pulp and paper, lumber and wood products, food products, and other manufacturing industries by service area and subbasin where applicable. The projected raw waste loads are expressed in population equivalents to relate different waste sources to a common base. This equivalency applies only to the oxygen-demanding properties of a waste.

The most important quality effect at present and for some time in the future is the demand made on the oxygen resources of the river system. The oxygen demand of organic wastes is the principal drain on the oxygen in water.

Municipal waste sources will tend to become more concentrated in the four large service areas of the basin. The dominant source of municipal wastes will continue to be the Portland Service Area, which includes the urban population of the Tualatin Subbasin. At present, approximately 51 percent of the wastes generated in this service area go directly to the Columbia River, and in the future at least this percentage will continue to be discharged, after treatment, to that river.

Table 124 - Projected Population, Subregion 9 1/ (10)

	1980	2000 (thousands)	2020
Upper Willamette Subbasin			
Eugene-Springfield Service Area a	212.4	301.5	438.9
Municipal	198.7	288.0	426.5
Rural	13.7	13.5	12.4
Other	70.1	88.5	125.1
Municipal	30.7	50.5	90.2
Rural	39.4	38.0	34.9
Subtotal	282.5	390.0	564.0
Municipal	229.4	338.5	516.7
Rural	53.1	51.5	47.3
Middle Willamette Subbasin			
Albany-Corvallis Service Area	98.7	143.5	210.5
Municipal	98.7	143.5	210.5
Rural	--	--	--
Salem Service Area	160.7	222.5	311.6
Municipal	160.7	222.5	311.6
Rural	--	--	--
Other	178.3	190.0	206.9
Municipal	87.6	107.7	134.6
Rural	90.7	82.3	72.3
Subtotal	437.7	556.0	729.0
Municipal	347.0	473.7	656.7
Rural	90.7	82.3	72.3
Lower Willamette Subbasin			
Portland Service Area	939.2	1,320.2	2,065.5
Municipal	939.2	1,320.2	2,065.5
Rural	--	--	--
Other	108.1	155.8	232.5
Municipal	20.0	32.3	52.3
Rural	88.1	123.5	180.2
Subtotal	1,047.3	1,476.0	2,298.0
Municipal	959.2	1,352.5	2,117.8
Rural	88.1	123.5	180.2
TOTAL SUBREGION	1,767.5	2,422.0	3,591.0
Municipal	1,535.6	2,164.7	3,291.2
Rural	231.9	257.3	299.8

1/ The municipal population is defined as that population discharging wastes to a municipal sewerage system. The rural population is defined as the residual.

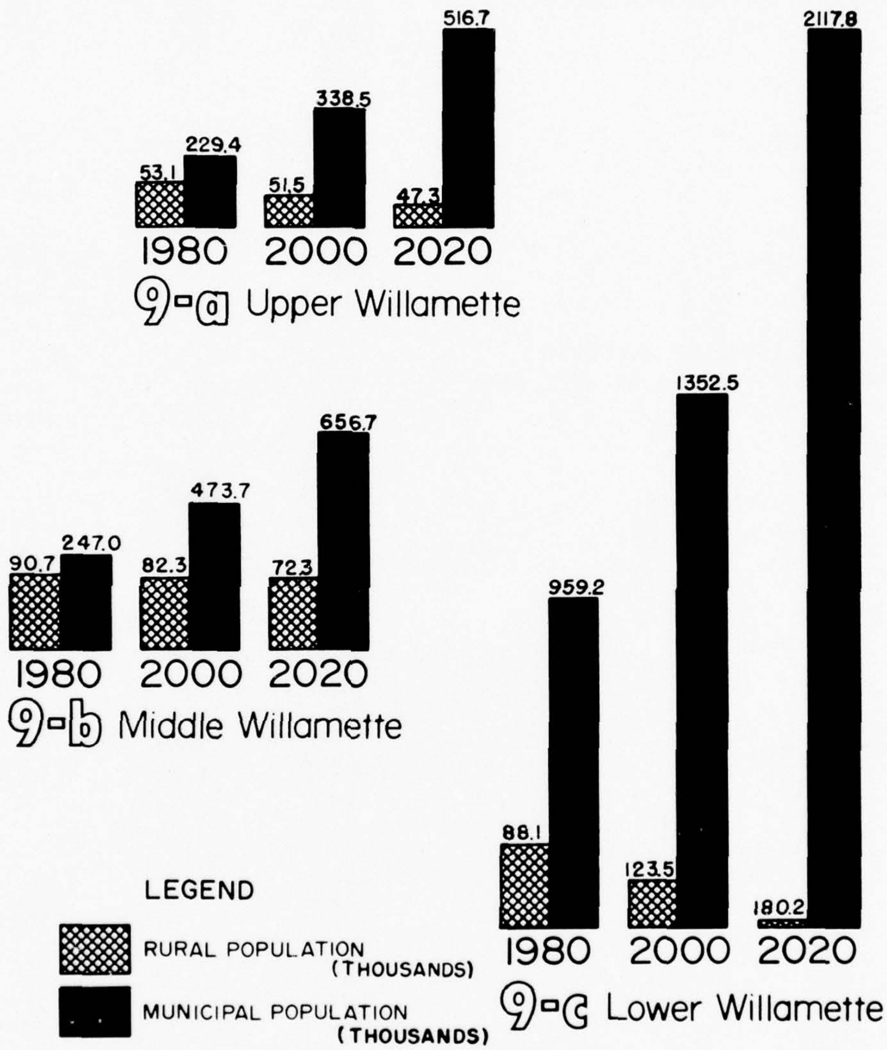


FIGURE 97. Projected Population, Subregion 9

Table 125 - Projected Raw Waste Production, Subregion 9 1/ (10)

	1980	2000	2020
	(waste loads in PE's)		
Upper Subarea			
Municipal	286,900	423,000	645,800
Industrial			
Pulp & Paper	900,000	1,460,000	1,820,000
Food Products	200,000	336,000	500,000
Lumber & Wood Products	4,600	3,900	3,700
Rural-Domestic	53,100	51,500	47,300
Middle Subarea			
Municipal	433,800	592,100	820,800
Industrial			
Pulp & Paper	957,000	1,298,000	1,611,000
Food Products	969,000	1,368,100	1,959,000
Lumber & Wood Products	242,600	304,600	313,600
Manufacturing	2,200	3,100	4,800
Rural-Domestic	90,670	82,300	72,300
Lower Subarea			
Municipal	1,195,100	1,684,600	2,637,300
Industrial			
Pulp & Paper	530,000	728,000	853,000
Food Products	162,000	228,000	338,000
Lumber & Wood Products	167,000	211,000	219,000
Manufacturing	7,500	14,000	30,000
Rural-Domestic	88,100	123,500	180,200
Total Willamette Basin			
Municipal	1,915,800	2,699,700	4,103,900
Industrial			
Pulp & Paper	2,387,000	3,486,000	4,284,000
Food Products	1,331,000	1,932,100	2,797,000
Lumber & Wood Products	414,200	519,500	536,300
Manufacturing	9,700	17,100	34,800
Rural-Domestic	231,870	257,300	299,800

1/ Industrial raw waste production derived from growth indices, with consideration given to expected changes in in-plant processes and technology.

In the Willamette Basin, the pulp and paper industry discharges over 3/4 of the total waste load to the stream system. Since the accuracy of projected flow augmentation needs in the river system rests primarily upon the soundness of industrial production predictions, projections of pulp and paper waste loads were based on the following assumptions:

1. There will be no future growth in sulfite pulping.

2. Groundwood and sulfate pulping will share in future growth in the same proportions they now exhibit.

3. The future mix between bleached and unbleached pulp will equal that expected for the Pacific Northwest by 2020 (90 percent bleached), with the mix over the intervening years determined by linear interpolation from the present mix.

4. The locations of future pulp production will approximate present locations.

5. Future increases in pulp production will be converted to paper. At present, the basin is a net exporter of pulp.

6. The rates of production of oxygen-demanding raw wastes per unit of product are based on the assumption that proper in-plant controls and chemical recovery will be in operation.

The food products industry will continue to grow throughout the basin, and the canning and preserving sector is expected to increase approximately three and one-half times by the end of the projections period. It should be noted, however, that the food products waste projections do not reflect this expected increase in overall production, because these processing wastes can largely be treated by the same systems used for municipal effluents. Therefore, it is expected that a greater proportion of these wastes will be treated by joint municipal facilities rather than by separate industrial treatment plants.

The lumber and wood products industry is expected to decline over the projection period. Since this industry is also required to provide proper treatment, it is not expected to have much effect on overall water quality in the basin.

The greatest relative increase in industrial activity is expected to occur in the "other" manufacturing industries. The potential waste problems which may result are difficult to quantify. Much of the growth will occur through the establishment of small concerns whose waste output can logically be handled by municipal treatment facilities. Again, great reliance must be

placed on the water pollution control authorities to assure that all wastes from these diverse sources will be properly handled.

Presently, five fuel-fired generating plants of 5,000 kilowatts or more are operating intermittently, using river water for cooling purposes. They are operated mainly in the winter when temperatures are low and streamflows are high. These plants pose no water quality problems at present, and are not expected to create any in the future. Potential development of thermal-nuclear powerplants needed in the basin will require careful planning to properly preserve water resources and the environment. A number of nuclear powerplant sites are being studied. A research project is currently underway to determine the feasibility of using water warmed by thermal plants to beneficially irrigate farmland.

Irrigation

Irrigated acreage is expected to expand significantly throughout the basin. Projections show that the 1965 level of 244,000 acres will expand to 430,000 acres by 1980; 850,000 acres by 2000; and 1,000,000 acres by the year 2020. Since the estimated land available for agricultural purposes will be 1,371,000 acres in 2020, a very high dependence on irrigation for agricultural production is envisioned. Because of the climatic regime and irrigation practices, water quality problems resulting from return flow should continue to be minimal. However, seasonal low streamflow resulting from depletions of this water may well affect the ability of the water resource to serve the needs of the fishery, recreation, and water quality uses.

Other Land Uses

Projections of land use in the subregion, by major types of land, are shown in table 126.

Table 126 - Present and Projected Use of Land, Subregion 9 (5)(8)

	1966	1980	2000	2020
		(thousands of acres)		
Land Use				
Cropland	1,456	1,384	1,420	1,250
Irrigated	(244)	(417)	(824)	(970)
Nonirrigated	(1,212)	(967)	(596)	(280)
Forest	5,272	5,221	5,056	5,089
Range 1/	59	55	50	48
Other 2/	816	911	1,031	1,156
Total	7,603	7,571	7,557	7,543

1/ Does not include forest range.
2/ Includes barren land, roads, railroads, small water areas, urban and industrial areas, farmsteads, airports, etc.

Agricultural Animals

The raw organic waste production by the livestock population in the subregion is expected to be equivalent to that from a population of 3,000,000 in 1980; 4,000,000 in 2,000; and 5,200,000 in 2020. This is approximately 35 percent of the estimated total organic waste production for the subregion. Most of the waste remains on the land and decomposes by natural processes. It is expected that a larger percentage of the cattle will be on feedlots by the year 2020, as compared to those presently on lots. Animals concentrated in feedlots along streams cause accelerated erosion as well as intensifying to potential coliform bacteria, nutrients, and biochemical oxygen demand in the water

Recreation

The projected raw production by recreation activities in the subregion is summarized as follows:

Year	Population Equivalents 1/
1970	169.4
1980	229.0
2000	428.2
2020	801.2

1/ Bureau of Outdoor Recreation and U.S.D.A. Forest Service Projections for total man recreation days (TMRD).

In the determination of wastes from recreation activities, the population equivalent is based on the total average recreation days. The values represent the daily raw waste production for a typical summer weekend.

Water Quality Goals

In the Willamette Basin, the protection and enhancement of instream uses, both present and future, determine the necessary future demand for quality control. The following subbasin presentations give the primary considerations for future protection of the water resource from a quality standpoint.

Municipal and industrial water supplies, production of salmonid fish, and recreation are the principal quality-demanding uses in the Upper Willamette Subbasin. Irrigation and stock watering, uses of lesser extent, are growing fast but impose no additional quality requirements.

The primary water quality objectives are those relating to dissolved oxygen, temperature, and bacteria. Maintenance of a dissolved oxygen level of at least 7 mg/l throughout the waters of the Upper Subbasin is necessary in view of the large part the area plays in maintaining salmon runs. In spawning areas, influences that result in a deviation from oxygen saturation should be eliminated. Except in the lower Long Tom River, where natural conditions are not suitable, summer water temperatures that do not exceed 70 degrees may be considered a desirable fishery objective; the warm-water game fish in the lower Long Tom do not impose as strict a temperature requirement. Bacterial concentrations below 1,000 MPN per 100 ml should be established wherever possible. In reservoirs which have extensive summer water-contact recreation, the bacterial objective is critical. Lowering the bacterial density of the Willamette near Eugene, in particular, would provide desirable water-contact recreation for the large population of the Eugene-Springfield area.

The principal quality-demanding uses of water in the Middle Willamette Subbasin are for salmonid fish, municipal and industrial water supply, and recreation. Considerable irrigation demand for surface water also exists.

The primary water quality objectives are those relating to dissolved oxygen, temperature, and bacteria. Maintenance of a dissolved oxygen level of 6 mg/l in all waters not otherwise unsuitable by reason of temperature is necessary to fish production. In the lower stretches of Rickreall Creek and Marys, Luckiamute, Pudding, Yamhill, and Calapooia Rivers, where summer temperatures customarily exceed 70°F., at least 6 mg/l of dissolved oxygen are required in order to accommodate fish passage needs. Streams providing water-contact recreation should maintain bacterial concentrations of less than 1,000 MPN per 100 ml. Attainment of this objective in the Willamette River is highly desirable, because the river has a high potential to meet the Middle Subbasin's water recreation needs and because of the concentration of population along its banks.

The Lower Willamette Subbasin includes the Tualatin, Clackamas, Columbia and Sandy Basins. As in the Upper and Middle Subbasins, the principal quality-demanding uses of water are for the passage of salmonid fish, municipal and industrial water supply, and recreation. Irrigation demands are slight except in local areas.

Because of the nature of uses, the primary water quality objectives for the Lower Subbasin are those relating to dissolved oxygen, temperature, and bacteria. Maintenance of at least 6 mg/l dissolved oxygen, and saturation where possible, in the entire Clackamas and Sandy Rivers and in the reach of the Tualatin River above Rock Creek (RM 38) is required for anadromous fish spawning. In reaches such as the Tualatin below Rock Creek and the Willamette, where natural summer temperatures and hydraulic characteristics make such an objective unreasonable, a minimum of 5 mg/l must be maintained to permit anadromous fish passage to higher quality tributaries.

The maximum temperature criterion for anadromous fish life in the lower Willamette and Tualatin Rivers is 70°F. (21.1°C.). It should be realized, however, that such a temperature level will be difficult to maintain in the lower Tualatin without substantial increases in flow. On all reaches of streams used for water-contact recreation, bacterial concentrations should not be greater than 1,000 MPN. Attainment of this objective in the lower Willamette and lower Tualatin Rivers will help to realize the recreation potential of the Lower Subbasin. For decades, the recreation resource has suffered because of poor water quality.

MEANS TO SATISFY DEMANDS

Providing water quality sufficient to adequately serve the river system's functions of water supply, fish habitat, and recreation will require a coordinated program of waste reduction, flow regulation, application of waste-controlling techniques, and a system of cooperative management of the watershed for pollution control. Following is a summary of all the measures necessary to preserve the basin's water quality.

A compelling need is coordination of the activities of all agencies which have a responsibility within the program. Among these, the Department of Environmental Quality (DEQ) and the Environmental Protection Agency (EPA) are the paramount state and Federal agencies among the many groups having either a regulatory or effective interest in pollution control in the Willamette Basin.

Waste Treatment

Waste reduction through effective treatment is the critical requirement for an effective water quality management program in the Willamette Basin.

The implementation and enforcement plan for the public waters of the State of Oregon requires that all municipalities and industries in the Willamette Basin provide a high level of waste treatment. For those not already providing secondary treatment or its equivalent, such treatment must be in operation by July 1972.

The single, most necessary element to end existing pollution in the Willamette Basin is the immediate installation of waste treatment facilities at all pulp and papermills presently without them, together with equipment to condense and burn, or otherwise dispose of, sulfite waste liquors.

Long-term waste treatment needs will impose a continuing requirement for treatment plant construction. The substantial growth of population and industrial output will be a source of sustained pressure on treatment capabilities. Obsolescence of existing plants will cause treatment needs to become increasingly acute during the early 1980's when a large number of plants built in the late 1950's and early 1960's will require replacement. In most areas, higher degrees of treatment will be necessary; advanced waste treatment is fast becoming a necessity in the densely populated Tualatin Basin.

Treatment Costs

Curves showing the total construction and annual operation and maintenance costs of municipal sewage treatment plants are presented in the "Means to Satisfy Demands" section of the Regional Summary.

Other Pollution Control Practices

While waste treatment and flow regulation are the major measures for meeting pollution control needs--as well as the major source of future capital expenditures--additional methods of control should be diligently pursued.

The immediate need in this regard is for the City of Portland to complete its system of trunk sewer interception to eliminate discharges of untreated wastes into Portland Harbor.

The municipality is actively working to this end; interception costs compose the major portion of a $14 million waste control budget adopted in 1965.

Measures supporting water quality, which may readily be adopted in the near future, include the stoppage of untreated waste discharges from houseboats and oceangoing commercial vessels to Portland Harbor. The DEQ has statutory authority to prohibit untreated discharges, and the FWPCA has completed a study determining the extent of these wastes and devising means of controlling them. The DEQ has now established requirements with deadlines for the management of wastes from houseboats.

The control of fertilizers and commercial toxicants through careful application practices is of more than passing importance, in view of their increasing use. The U. S. Department of Agriculture, which has the responsibility for regulation of such materials, should make a major effort--ideally through the county extension agents--to insure that use practices which fully reflect the need for protection against all types of environmental pollution are adopted by the individual farmers and commercial applicators. Soil-stabilizing practices must continue to be effectively promoted for agriculture, logging practices, construction, channel improvements, and other activities that cause or affect deposition of soil in water bodies. In particular, soil stabilization should be included as a condition of all contracts let by Federal agencies and by contractors engaged in work where Federal grants are involved. The responsibility for such actions is imposed upon Federal agencies by the terms of Executive Order 11507: Prevention, Control, and Abatement of Air and Water Pollution at Federal Facilities.

Similar controls by state and local agencies would be of great value, particularly if statutory authority for inspection and summary powers of abatement were awarded to the DEQ. Controls should be adopted by the State of Oregon to prevent free access of concentrated animal populations (as at feedlots and dairies) to banks of water bodies. Acceleration of the City of Portland's program to control urban runoff would also be of great value. Economies could be affected by incorporating appropriate design features into the new interceptor sewer systems that will be constructed in the near future.

Over the longer term, a systematic handling of the problems posed by urban storm-water runoff and combined sewer overflow at waste treatment plants must be undertaken. The major need in this regard is development of methods. The cost of separating existing combined sewer systems is so great that it does not at this time represent a practical alternative. Based on costs per

person developed in national studies, about $250 million would be required for the Willamette Basin.

Minimum Flow Requirements

Waste treatment alone cannot provide the level of quality that is desired in the Willamette Basin. Because of the association of pollution with depleted summer flows, augmentation of flow by regulated releases from basin reservoirs is necessary for an effective pollution control program.

Flow requirements were determined by mathematically modeling the dissolved oxygen system of the Willamette River. The model essentially computed the oxygen demand that the projected waste loadings exerted on the river through a series of river reaches, and determined the required flows to satisfy the oxygen demand and still meet the state standards for dissolved oxygen in each reach. The model was run for two temperature conditions, the first presuming cold-water releases from the storage reservoirs during the summer operation; the second presuming ambient, warm-water releases during that period. Wastes entering the stream for each projection horizon were calculated by reducing the raw wastes determined from the economic projections by an assumed treatment efficiency level which would be in effect.

To apply this model to future conditions, several assumptions were necessary, certain of which were outlined below to show some of the limitations and areas for future refinement of the present analysis. Growth of the major waste-producing industries was assumed to occur in the same pattern as existed in 1965. Except for the pulp industry, relative unit waste loads were expected to persist as at present. For those industries that presently do not discharge their wastes into the Willamette River because of use of lagoons or land application, it was assumed that future residual wastes, following adequate treatment, would be discharged to the river system. Oxygen content of treated effluents and levels of removal of BOD from domestic and industrial wastes were assumed to be the following:

Willamette Basin, Except for Tualatin Basin

	1980	2000	2020
BOD removal	85%	90%	90%
DO in effluent	1 mg/l	1 mg/l	5 mg/l

It was assumed that effluents containing industrial wastes would have no dissolved oxygen in 1980.

	1980 BOD Removal	2000 BOD Removal	2020 BOD Removal
Non-Urban Tualatin Basin			
Forest Grove	90%	90%	95%
Hillsboro	90%	90%	95%
Cornelius	90%	90%	95%
Others	90%	90%	95%
Urban Tualatin Basin			
Beaverton area	90%	95%	95%
Fanno Creek area	95%	95%	95%

The projected flows required for water quality for the Willamette system are summarized in table 127. Increased flows are needed in the main stem Willamette in the vicinity of Albany and in Portland Harbor. Tributaries having projected flow needs are the Yamhill, Pudding, South Santiam, and Tualatin Rivers, and Rickreall Creek. These areas are discussed briefly below.

The Yamhill River's flow regulation need is significant in light of an extensive appropriation of water rights and the development of the Red Prairie Project of the U.S.D.I. Bureau of Reclamation, which is expected to increase the use of the river for irrigation. Existing water rights, if exercised, would deplete the flow of the river entirely during low-flow periods. Part of the water quality objectives could be achieved from storage in the proposed Red Prairie Project. It is assumed that the remaining flows required would be derived from other storage constructed in the Yamhill Basin.

Need for flow augmentation is indicated also for the Pudding River. It was assumed that the food industry, which currently utilizes land disposal for its wastes, would expand according to the industrial growth index for the Middle Willamette Subbasin and by 1980 would discharge treated waste effluent to the Pudding River.

The South Santiam River's flow regulation requirements arise as a result of the waste discharges of a pulp and paper plant at Lebanon. The municipalities and industries along the river, including the pulp and paper plant, provide a high level of waste treatment; the DEQ has instructed the pulp mill to limit its summer waste discharges to about five percent of the original strength of its gross waste production.

Projected flow requirements for the North Santiam are based on the assumption that industry would expand in proportion to the indexes shown for the Middle Willamette Subbasin and would discharge treated effluents to the river system. A very

substantial industrial waste load presently is retained in lagoons or is used for irrigation of crops. The largest projected waste load in the North Santiam Basin is from the cannery industry. If the projected growth is realized, the future minimum flow requirements for the North Santiam will approximate the present one-in-ten-year low flow of the stream.

The Tualatin River's need for augmented summer flows is perhaps the most immediate and pressing in the Willamette Basin. The average level of waste reduction already exceeds 90 percent, but dissolved oxygen in the lower river consistently drops well below 5 mg/l. Depletion of summer flows is a factor contributing to this problem. Examination of other water quality parameters exhibits an equally dismal picture. Any long-term solution to the water quality problems in the Tualatin will result from the integration of waste treatment and a suitable minimum flow regime.

Analysis of Portland Harbor showed that required water quality flows were rather insensitive to upstream treatment levels, while the harbor hydraulic characteristics and benthic loading exerted significant effects. Flows derived from the model understated the demands of these undefined factors, requiring further study to account for them in the recommendations. The reanalysis resulted in flow requirements during July and August through Portland Harbor of 6,200 cfs in 1980; 6,300 cfs in 2000; and 7,500 cfs in 2020.

Meeting these flow needs will require storage releases from upstream Willamette reservoirs. Portland Harbor flows will probably control regulation requirements for water quality control in the Willamette system. Achievement will be complex because of conflicting water uses and the operational schedules of reservoirs that came into being before water quality control was a legally sanctioned function of Federal storage projects.

Authorized purposes of the Willamette Basin Project reservoirs are flood control, navigation, power generation, and irrigation. The Army Corps of Engineers, in their 1947 authorizing report, expressed their intent to manage the system in a manner that would provide a minimum navigation flow at Salem of 5,500 cfs upon completion of all authorized projects. This minimum level of flow has been the basis used by the DEQ in establishing its policies with regard to waste discharges into the Willamette. Maintenance of a comparable flow through Portland Harbor would meet the water quality objectives. In particular, it would assure maintenance of a DO concentration of 5 mg/l, which is needed to maintain salmon runs.

Table 127 - Water Quality Flow Requirements in the Willamette River and Tributaries, 1980-2020

WATER QUALITY FLOW REQUIREMENTS 1/
WILLAMETTE RIVER

	1980 (cfs)							2000 (cfs)							2020 (cfs)						
	Nov-Apr 2/	May	June	July	Aug	Sept	Oct	Nov-Apr	May	June	July	Aug	Sept	Oct	Nov-Apr	May	June	July	Aug	Sept	Oct
Eugene	20	20	25	40	40	35	25	25	25	30	45	45	40	30	25	40	45	60	60	50	40
Harrisburg	700- 900	1200	1300	1400	1600	1400	1200	1000-1100	1400	1500	1700	1800	1700	1400	1100-1200	1600	1800	1900	2100	2000	1600
Albany	1300-1600	2000	2000	2400	3000	2800	2500	1700-1900	2400	2400	3200	3500	3200	2900	1800-2100	2500	2700	3300	3900	3600	3000
Salem	1400-1700	2100	2100	3200	3700	3000	2600	1700-2000	2500	2500	4100	4400	3500	3000	2000-2200	2600	2900	4200	4800	4000	3100
Oregon City	1600-1900	2400	3100	5000	5000	4200	2800	2000-2400	2900	3200	5200	5100	4300	3300	2400-3100	3100	3900	6100	6300	5100	3600
Portland Harbor	1600-2400	3200	4200	6200	6200	5100	3000	2000-2500	3300	4300	6300	6300	5200	3300	2700-3100	4100	5100	7500	7500	6200	3700

WATER QUALITY FLOW REQUIREMENTS
WILLAMETTE RIVER TRIBUTARIES

	1980 (cfs)							2000 (cfs)							2020 (cfs)						
	Nov-Apr 4/	May	June	July	Aug	Sept	Oct	Nov-Apr	May	June	July	Aug	Sept	Oct	Nov-Apr	May	June	July	Aug	Sept	Oct
Coast Fork 3/	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	30	30	30	30	20
Middle Fork	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
McKenzie	110-140	170	190	220	220	190	160	140-180	210	230	270	270	240	200	140-170	210	230	270	270	240	190
No. Fork Santiam	10	10	20	590	590	110	10	10	10	20	760	780	150	10	20	20	20	680	690	130	20
So. Fork Santiam	20- 30	30	40	50	50	50	40	20	20	30	40	40	40	30	20	30	30	40	40	40	30
Santiam	35- 40	50	60	620	640	160	50	40	40	50	810	820	180	50	40	40	50	720	730	160	40
So. Fork Yamhill	20	20	30	60	60	50	20	10	20	30	50	50	40	20	10	10	20	30	40	30	10
Yamhill	20	30	40	80	80	60	30	10	20	30	70	70	60	20	20	20	30	70	70	50	20
Pudding	20	20	40	120	130	100	20	20	20	30	120	140	100	20	20	20	30	150	160	130	20
Tualatin nr Freeway	50-110	60	90	180	180	160	80	80-150	70	100	220	220	200	90	110-190	90	120	210	210	190	100
Tualatin at Mouth	40-130	30	40	140	140	120	30	90-200	50	80	210	210	170	60	110-250	90	140	270	260	200	100

1/ Summary, more refined breakdown available from FWPCA.

2/ Vale Values shown represent ranges of flow during period.

3/ All flows are for lower reach of tributary, except Tualatin River near freeway.

4/ Values shown represent ranges of flow during period.

Management Practices

Measures necessary to abate water pollution in the Willamette Basin are straightforward, but they are not in themselves sufficient to guarantee the maintenance of water quality. Continuing management decisions and procedures with clearly defined responsibilities among those interests concerned with water quality and water pollution control will also be necessary.

The DEQ and FWQA are the agencies with primary responsibility for water pollution control. These two agencies must have full participation in reaching decisions related to water use and management which affect water quality control.

LOCATION MAP

SUBREGION 10

S U B R E G I O N 10

C O A S T A L

INTRODUCTION

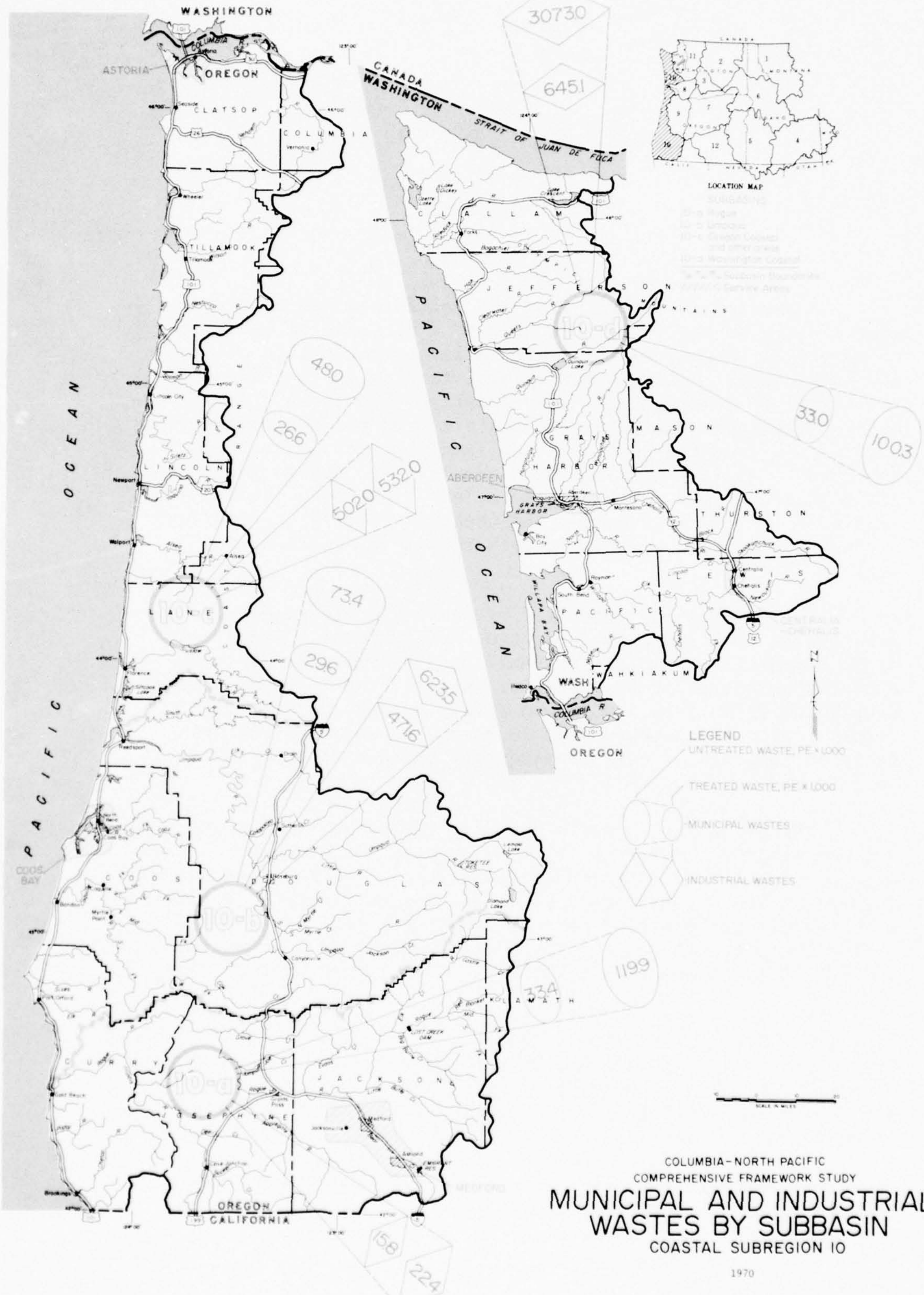
Subregion 10 extends from the California border to the northern tip of the Olympic Peninsula, a distance of 500 miles. It covers an area of 23,763 square miles in the states of Oregon and Washington. Hilly to mountainous terrain is continuous from the Strait of Juan de Fuca to the Siskiyou Mountains. About one-half of the snowcapped Olympic Mountains and the Coast Range plus part of the southern Cascade Range and Siskiyous, are in the subregion. Elevations range from sea level to nearly 10,000 feet, although elevations are generally below 3,000 feet. With the exception of the Rogue, Umpqua, and Chehalis Valleys, the valleys are usually narrow, widening only within a few miles of the Pacific Ocean.

The area is characterized by a mild, moist climate. Temperature is modified greatly by the Pacific Ocean. Hourly and daily temperature ranges are small, and extremes rarely occur. With the exception of the interior valleys, temperatures seldom drop below 0° F. (-17.8° C.) and rarely exceed 100° F. (37.8° C.). Precipitation totals vary from 20 to 200 inches, most of which falls in the form of rain from October through March with little in July and August.

The principal economic force is timber harvesting and processing although commercial fishing, recreation, and agriculture also are important. Outstanding recreational attractions abound throughout the coastal areas of Oregon and Washington. Beginning with the Olympic National Park and extending southward to the southern Oregon beaches are the most popular and well-developed recreation resources of the Columbia-North Pacific Region.

The population was about 425,800 people in 1965, of whom 41 percent live in the five major service areas. The larger towns are generally located along bays or in the interior along major streams. There is much rural land, resulting in an overall low density of settlement. Along the coast of Washington are six small Indian reservations.

The Coastal Subregion is divided into the Rogue, Umpqua, Other Oregon Coastal Areas, and Washington Coastal Subbasins.



COLUMBIA–NORTH PACIFIC
COMPREHENSIVE FRAMEWORK STUDY

MUNICIPAL AND INDUSTRIAL WASTES BY SUBBASIN

COASTAL SUBREGION 10

1970

FIGURE 98

The major service areas are the Medford, Coos Bay, Astoria, Chehalis-Centralia, and Aberdeen areas.

PRESENT STATUS

Municipalities and industries are the most important sources of organic wastes in the Coastal Subregion. A graphical summary of the municipal and industrial waste production and discharge is presented for each subbasin in figure 98. The pulp and paper industry accounts for about 87 percent of the total waste discharge. Land use and management practices and runoff from agricultural animals are also significant pollution sources. Navigation and dredging operations, irrigation diversions, and return flows have resulted in localized problems.

The economy of subregion 10 is dependent upon good quality water. High quality water in the ocean, its estuaries, and its rivers provides the major attractions which bring tourists and recreationists into the area. The most commonly encountered water quality problems include high coliform bacterial counts, high temperatures, and high nutrient levels. A few instances of low dissolved oxygen are found, and high turbidities and sedimentation are experienced during some periods of the year.

Stream Characteristics

Some 21 moderately sized streams discharge from the subregion into the Pacific Ocean. The largest of these are the Rogue, Umpqua, and Chehalis Rivers. Some of these streams flow into bays, while others empty directly into the Pacific Ocean.

The average annual runoff amounts to about 87,600 cfs (63.5 million acre-feet)--the largest of any subregion in the Columbia-North Pacific Region. This provides an average discharge of 3.7 cfs per square mile--the second highest rate of runoff in the region.

Surface-Water Hydrology

The discharge pattern of streams in the coastal area coincides with the precipitation pattern. Maximum flows occur during the months of December, January and February--a direct result of runoff from precipitation and melting snow. Minimum flows occur in August and September. However, streams draining the glacial areas of the Olympic Peninsula maintain relatively high flows even during August and September. In terms of volume, over 80

Table 128 - Average Monthly Discharge, Subregion 10 (12)

Location	Jan.	Feb.	March	April	May	June	July (CFS)	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
Nehalem River near Foss, Ore.	5,913	6,044	4,486	2,907	1,256	604	250	138	158	801	3,473	6,074	2,675
Wilson River near Tillamook, Ore.	2,380	2,333	1,850	1,223	620	334	174	107	150	369	1,795	2,723	1,171
Siletz River at Siletz, Ore.	3,138	3,022	2,377	1,579	809	455	216	126	167	762	2,185	3,418	1,521
Alsea River near Tidewater, Ore.	3,642	3,361	2,664	1,682	807	434	197	118	122	462	1,745	3,311	1,545
South Umpqua River near Brockway, Ore.	6,421	6,470	4,869	3,337	1,853	977	266	126	114	552	1,999	5,017	2,667
North Umpqua River near Toketee Falls, Ore.	399	393	391	435	563	548	418	371	350	347	359	388	414
Umpqua River near Elkton, Ore.	15,421	15,385	12,390	8,963	6,277	4,042	1,742	1,132	1,093	2,031	6,216	13,443	7,353
South Fork Coquille River near Powers, Ore.	1,883	1,662	1,313	883	468	194	68	35	32	245	964	1,714	785
Coquille River at Coquille, Ore.	7,510	6,599	5,214	3,520	1,859	769	272	140	125	971	3,827	6,739	3,129
Rogue River at Dodge Bridge, Ore.	3,381	3,672	3,370	3,372	3,478	2,587	1,448	1,134	1,082	1,222	1,849	2,991	2,465
Rogue River at Grants Pass, Ore.	5,306	5,597	4,814	4,425	4,141	2,936	1,358	1,040	1,014	1,482	2,280	4,417	3,235
Illinois River at Kerby, Ore.	2,840	2,611	1,993	1,551	982	437	112	47	40	313	1,180	2,393	1,208
Rogue River at Gold Beach, Ore.	25,049	22,624	19,100	13,850	10,938	5,685	2,322	1,480	1,439	3,519	9,147	20,236	11,290
Naselle River near Naselle, Wash.	836	833	615	403	193	133	77	51	78	304	666	928	425
North River near Raymond, Wash.	2,018	1,929	1,424	954	424	251	110	79	121	504	1,309	2,215	941
Chehalis River near Grand Mound, Wash.	6,089	6,098	4,475	2,900	1,267	780	353	217	242	937	3,589	6,235	2,761
Satsop River near Satsop, Wash.	3,961	3,718	2,877	2,072	1,106	679	428	309	380	1,171	2,653	3,976	1,944
Wynoochee River near Aberdeen, Wash.	1,402	1,256	921	845	629	459	280	174	224	641	1,169	1,534	788
Quinault River at Quinault Lake, Wash.	4,116	3,633	2,736	2,684	2,926	2,752	1,822	910	841	2,203	3,827	4,775	2,766
Hoh River near Forks, Wash.	2,707	2,410	1,730	1,735	1,893	2,000	1,668	1,139	1,042	1,757	2,615	3,143	1,991
Soleduck River near Fairholm, Wash.	947	816	559	607	654	587	339	164	146	410	818	1,093	597

percent of the average annual yield occurs during the six wet months. Table 128 presents average monthly discharge data for selected stations.

From the standpoint of waste discharge control, the low-flow months of July, August, September, and October are the most important. Throughout the subregion, August and September are the most critical months because this is the time of year when lowest flows coincide with maximum consumptive uses. Average runoff during August and September amounts to only two percent of the yearly total, and problem areas occur in tidal zones and in the inland Rogue, Umpqua, and Chehalis valleys. One-in-ten-year low flows are the selected recurrence frequency for prediction of critical low flows. These data for selected stations are summarized in table 129.

Impoundments and Stream Regulation

Major impoundments constructed or authorized for irrigation, flood control, power, recreation, water supply, and fishery enhancement include Lost Creek, Elk Creek, and Emigrant and Applegate Reservoirs in the Rogue River system. Another large impoundment for municipal and industry water supply and flood control is on the Wynoochee River. In addition, there are a number of power plants in the Umpqua and Rogue River systems.

Ground-Water Characteristics

Ground-water resources of the subregion are limited in extent and use. The major ground-water reservoirs are the alluvial and beach deposits making up river flood plains, terraces, and coastal lowlands. In the southern interior permeable volcanic formations located in the higher Cascades form good aquifers. However, most of the subregion is made up of relatively impervious sediments and volcanics yielding only small to moderate amounts of water.

Alluvial deposits in the Medford area of the Rogue Subbasin and dune deposits along the coast provide yields of up to 500 gallons per minute (gpm) to individual wells without excessive drawdown. Glaciofluvial and glacial outwash deposits in the Chehalis Valley provide yields of 50 to 200 gpm. Other smaller areas have limited aquifers with known productivities of up to 2,000 gpm per well. However, the major portion of the subregion yields less than 20 gpm per well without exceeding the allowable draw upon the aquifer.

Table 129 - One-in-Ten-Year Low Flows, Subregion 10 (12)

Stream and Location	One-in-Ten-Year Low Flows (cfs) 1/
Nehalem River near Foss, Oregon	80
Wilson River near Tillamook, Oregon	66
Siletz River at Siletz, Oregon	67
Alsea River near Tidewater, Oregon	75
South Umpqua River near Brockway, Oregon	70
North Umpqua River near Toketee Falls, Oregon	250
Umpqua River near Elkton, Oregon	810
South Fork Coquille River near Powers, Oregon	17
Coquille River at Coquille, Oregon	65
Rogue River at Dodge Bridge, Oregon	720
Rogue River at Grants Pass, Oregon	690
Illinois River at Kerby, Oregon	21
Rogue River at Gold Beach, Oregon	900
Naselle River near Naselle, Washington	27
North River near Raymond, Washington	65
Chehalis River near Grand Mound, Washington	125
Satsop River near Satsop, Washington	210
Wynoochee River near Aberdeen, Washington	90
Quinault River at Quinault Lake, Washington	350
Hoh River near Forks, Washington	550
Soleduck River near Fairholm, Washington	60

1/ Period of one month.

The chemical quality of water from aquifer units in the subregion differs considerably. Waters from the younger alluvial aquifers which furnish most large ground-water supplies generally have low dissolved solids, seldom exceeding 250 mg/l. The water is most often a soft to moderately hard, calcium-magnesium bicarbonate type. However, high iron concentrations are a problem in many supplies. The waters in the older volcanic or sedimentary aquifer units are more highly mineralized, although the dissolved solids level is usually less than 500 mg/l. In addition, water at depth in the sedimentary units is commonly saline, and saline water is encountered within 100 feet of the surface in certain locations. The volcanic and sedimentary aquifers are extensively used for domestic or small public and industrial purposes.

Pollution Sources

The municipal and industrial waste treatment in the subregion is summarized by basin in table 130.

At present, municipalities and industries produce wastes equivalent to those from a population of approximately 4.6 million persons. Of this total, 87.9 percent is generated by the pulp and paper industry, 7.4 percent by municipalities, 1.6 percent by the lumber and wood products industry, and 3.1 percent by the food-processing industry.

Waste treatment and other means of waste reduction decrease the normal waste load to the subregion's waters by about 62 percent so that 1.76 million PE actually reach waterways.

Other significant sources of pollution include wastes from the rural-domestic population, irrigation, agricultural animals, land use and management practices, navigation and dredging, and natural sources. Land use and waste drainages from agricultural animals are probably the most important of these, since they contribute to sedimentation and coliform bacteria.

Municipalities

Rogue Subbasin Municipal waste treatment practices in the Rogue Subbasin are generally adequate. An average reduction of 73 percent in the biochemical oxygen demand is accomplished so that about 33,370 PE are discharged to waterways. Of the ten communities with waste collection and treatment facilities, eight have adequate secondary treatment or lagoons. The remaining communities operate primary waste treatment plants.

In the upper Rogue River Valley, the Medford Service Area represents a major municipal waste source. A waste loading of about 3,600 PE is normally discharged from the service area to Bear Creek and the Rogue River. However, from August to October, food-processing wastes discharged to the municipal system of Ashland and Medford result in a waste loading of over 25,000 PE. During this period, about 9,000 PE are released to Bear Creek, and the remainder is released to the Rogue River. All communities in the area operate secondary waste treatment plants or waste stabilization ponds.

The City of Grants Pass discharges an organic waste loading of 3,000 PE to the Rogue River from a secondary treatment plant in need of upgrading.

Table 130 - Summary of Municipal and Industrial Waste Treatment, Subregion 10

	Municipal					Industrial			
	Primary	Secondary	Lagoons	Other	Total	Pulp and Paper	Lumber & Wood Prod.	Food Products	Total
Rogue Subbasin									
Number of facilities	2	4	4	---	10	---	10	6	16
Population served	5,050	53,300	4,620	---	62,970				
PE produced	5,400	109,760	4,750	---	119,910	---	18,510	3,900	22,410
PE discharged	3,900	28,740	730	---	33,370	---	15,270	480	15,750
% removal efficiency	28	74	85	---	73	---	18	88	30
Umpqua Subbasin									
Number of facilities	6	12	---	1	19	4	17	7	28
Population served	26,300	35,150	---	3,000	64,450				
PE produced	31,400	39,000	---	3,000	73,400	576,000	32,440	15,050	623,490
PE discharged	19,360	7,210	---	3,000	29,570	426,000	31,580	14,000	471,580
% removal efficiency	38	82	---	0	60	26	3	7	24
Other Oregon Coastal Areas Subbasin									
Number of facilities	5	6	3	4	18	3	5	19	27
Population served	7,490	16,350	2,260	11,550	37,650				
PE produced	8,100	21,950	2,420	15,550	48,020	519,240	6,810	5,960	532,010
PE discharged	5,370	5,460	320	15,550	26,610	489,240	6,810	5,960	502,010
% removal efficiency	34	75	90	0	45	6	0	0	6
Washington Coastal Subbasin									
Number of facilities	8	3	4	---	15	4	9	13	26
Population served	32,180	15,450	14,150	---	61,780				
PE produced	38,180	45,100	17,050	---	100,330	2,941,200	16,890	114,900	3,072,990
PE discharged	22,280	8,120	2,550	---	32,950	620,200	14,010	10,860	645,070
% removal efficiency	42	82	85	---	67	79	17	91	79
Total									
Number of facilities	21	25	11	5	62	11	41	45	97
Population served	71,020	120,250	21,030	14,550	226,850				
PE produced	83,080	215,810	24,220	18,550	341,660	4,036,440	74,650	139,810	4,250,900
PE discharged	50,910	49,530	3,510	18,550	122,500	1,535,440	67,670	31,300	1,634,410
% removal efficiency	39	77	86	0	64	62	9	78	62

1/ FWPCA inventory of Municipal and Industrial Wastes, Coastal Subbasin, 1965.

Other communities in the inland areas of the Rogue Subbasin account for only minor waste loadings. Generally, secondary treatment or lagoons are employed for waste treatment. However, a number of towns, the largest of which are Rogue River and Fruitdale, do not have sewer systems.

The communities of Gold Beach and Brookings, which discharge 1,800 and 2,100 PE, respectively, from primary treatment plants, are the principal municipal waste sources in the coastal area of the subbasin. The Oregon Water Quality Standards require that these communities install secondary treatment by July 1972.

Umpqua Subbasin An average reduction of about 60 percent in the municipal organic waste loading is accomplished, so that about 29,570 PE are released to the subbasin's waterways. Of the 19 municipal systems in the subbasin, 12 operate efficient secondary treatment plants. Six communities provide primary treatment plants, and one has no waste treatment.

The Coos Bay Service Area (which includes the communities of Coos Bay, North Bend, Empire, and Eastside and the Bunker Hill Sanitary District) is the largest municipal waste source. A total oxygen-demanding waste load of about 15,580 PE is released to Coos Bay. The prevailing level of waste treatment in the area is primary. The Oregon Water Quality Standards require that all municipal systems in the area upgrade to secondary treatment by July 1972.

The major municipal waste sources in the inland area of the Umpqua drainage are located along the South Umpqua River and its tributaries. All communities in this area operate adequate secondary treatment plants and represent a combined waste-water loading of about 4,900 PE. The City of Roseburg is the principal waste source, discharging 2,400 PE to the South Umpqua.

In the Coquille drainage, the communities of Myrtle Point, Coquille, and Bandon are the major waste sources. These communities discharge 1,500, 2,800, and 1,800 PE, respectively, to the Coquille River. Only Myrtle Point provides adequate secondary treatment, although the facility needs a secondary clarifier. At present, Coquille has primary treatment, and Bandon has no type of waste treatment. The Oregon Water Quality Standards call for secondary treatment at Coquille by July 1972. Secondary treatment is planned at Bandon as soon as financing can be arranged.

The community of Reedsport discharges about 3,000 PE of raw domestic sewage in the Winchester Bay area. The Oregon Water Quality Standards require secondary treatment by December 1968.

Other Oregon Coastal Areas Subbasin The average reduction in biochemical oxygen demand in this portion of the subregion is about 45 percent, resulting in an organic waste loading to waterways of about 26,610 PE. Of the 18 communities served by municipal waste systems, six provide secondary waste treatment, five operate primary waste treatment plants, three have waste stabilization ponds, and four have no waste treatment facilities.

The Astoria Service Area, which includes the communities of Astoria and Warrenton, is the largest municipal waste source, discharging about 15,100 PE of raw sewage to the Columbia River. The Oregon Water Quality Standards call for secondary treatment or the equivalent by December 1970.

Other important municipal waste sources are in the Seaside, Rockaway, Tillamook, Newport-Toledo, Lincoln City, and Florence areas. In general, wastes from these areas are released to streams shortly before the streams enter a bay or the ocean. Secondary treatment facilities are operated by all communities in these areas except Toledo and Florence. The Oregon Water Quality Standards require that secondary waste treatment be provided at Toledo by July 1970 and at Florence by July 1972.

The remaining communities in the subbasin with municipal waste collection systems represent relatively minor pollution sources. Only Garibaldi with primary waste treatment and Wheeler and Nehalem with no treatment provide less than adequate treatment. The Oregon Water Quality Standards require secondary treatment or the equivalent for these communities.

Washington Coastal Subbasin The average reduction in the biochemical oxygen demand in this subbasin is about 67 percent, resulting in an organic loading of about 32,950 PE to waterways. Of the 15 communities served by municipal systems, eight provide primary waste treatment, three operate secondary waste treatment plants, and four have waste stabilization ponds.

The major municipal waste source is the Aberdeen Service Area, which includes Aberdeen, Hoquiam, and Cosmopolis. These communities discharge a normal waste loading of about 17,400 PE to Grays Harbor. Cosmopolis and Aberdeen have primary treatment plants, and Hoquiam employs a waste stabilization pond. The Washington Water Quality Standards call for secondary treatment at Aberdeen and Cosmopolis and disinfection and outfall facilities at Hoquiam. These facilities will be constructed as soon as planning can be completed and financing arranged.

The Chehalis-Centralia Service Area is also an important municipal waste source. The communities of Chehalis and Centralia release about 4,000 and 1,200 PE, respectively, to the Chehalis River after secondary treatment. The Chehalis municipal system receives wastes from several year-round food-processing firms. In addition, from July to August, the system handles wastes from the National Fruit Canning Company, which result in an increase to about 6,800 PE in the waste-water strength.

The only other significant municipal waste sources are several communities along the Chehalis River and its tributaries and in the Willapa Bay area. Most of the communities have at least primary waste treatment, and several provide lagoons or secondary treatment. The Washington Water Quality Standards call for secondary treatment at Montesano, Raymond, and Westport by September 30, 1971; mid-1969; and December 31, 1969, respectively; and disinfection of the effluent from lagoons at Raymond and South Bend by mid-1969.

Industries

Rogue Subbasin Industrial waste production in the Rogue Subbasin is comparatively small the major industrial waste sources are the forest products and food-processing industries. These industries discharge 15,270 and 480 PE, respectively, to subbasin waterways.

The Medford Service Area accounts for 57 percent of the industrial waste loading. Plywood mills and several sawmills in the area discharge about 7,650 PE to Bear Creek. The food-processing industry generally utilizes septic tanks and subsurface disposal so that the waste load reaching streams is minor. Several food-processing industries also release wastes to municipal sewer systems.

Industries in the Grants Pass area discharge 3,210 PE to the Rogue River. The lumber and wood products industry discharges 2,750 PE, and the food products industry is responsible for the remainder.

The only other industrial oxygen-demanding waste loadings are contributed by plywood mills at Brookings and Gold Beach.

Sand and gravel operations are a source of sediment and inorganic materials discharged to several streams.

Umpqua Subbasin The total estimated industrial organic waste load produced in this subbasin amounts to about 623,490 PE. The principal waste sources are the pulp and paper, lumber and wood products, and food products industries. The three pulp and paper mills account for nearly 92 percent of the industrial waste production.

Industries in the Coos Bay Service Area discharge a normal waste loading of about 320,000 PE. A sulfite mill releases sulfite liquor wastes, white water, and hydraulic barker fines to Coos Bay without any type of treatment. The Oregon Water Quality Standards require that the timber company provide primary sedimentation or equivalent control of industrial waste solids. The DEQ is to determine the highest practicable treatment or control of the sulfite waste liquor. Waste treatment facilities at another sulfite mill consist of a primary settling basin and non-overflow ponds. Most of the remaining industrial waste production in the service area results from the lumber and wood products and food products industries. These industries discharge 6,720 and 13,000 PE, respectively, to Coos Bay--including untreated phenolic resin glue wastes, debris, and floating material.

The Gardiner-Reedsport area is an important industrial waste production center. A paper mill discharges about 120,000 PE to the Pacific Ocean through a deep-water outfall after primary settling. The company's plywood mill also provides primary sedimentation facilities and discharges the residual wastes to Winchester Bay. A dairy is the only other important waste source in the area, discharging about 1,000 PE to Winchester Bay without treatment.

The South and North Umpqua Rivers receive about 6,900 and 8,600 PE, respectively, of untreated wastes from the lumber and wood products industries in the Roseburg, Dillard, and Myrtle Creek areas. Cow Creek, a tributary of the South Umpqua, receives an organic waste loading of about 2,660 PE from the forest products industry and inorganic wastes from mining operations.

Other waste sources are several plywood and veneer mills scattered throughout the subbasin. These mills release about 8,900 PE, generally without any type of conventional treatment.

Other Oregon Coastal Areas Subbasin The total industrial waste production in this portion of the subregion amounts to about 532,010 PE, which are reduced to about 502,010 PE by waste treatment. The principal waste source is the pulp and paper industry, which accounts for about 98 percent of the industrial waste loading.

A paper mill at Toledo discharges about 168,000 PE to the Pacific Ocean and Yaquina River. Thermal reduction ponds and a deep ocean outfall are utilized for disposal of strong wastes. No treatment is provided for the white water. However, the Oregon Water Quality Standards require that primary sedimentation facilities be provided. Lumber and wood products industries in the Toledo area also discharge untreated phenolic resin glue wastes, debris, and floating materials.

A paper mill at Wauna discharges about 320,000 PE to the Columbia River. The mill provides good in-plant control procedures and primary sedimentation facilities.

The Astoria Service Area is an important source of industrial wastes. Two dairy associations contribute about 3,000 PE to the Wilson River. The Oregon Water Quality Standards require that these dairy products plants install secondary treatment. The Trask River receives an organic loading of about 600 PE from two slaughterhouses. The waste sources are near the mouths of the various rivers. Therefore, the effects of these wastes are, in part, transferred to Tillamook Bay. In addition, Tillamook Bay directly receives about 2,520 PE of untreated wastes from a plywood mill and several food products plants.

The remaining waste sources are comparatively small and are scattered throughout the subbasin.

<u>Washington Coastal Subbasin</u> Industrial waste production in this subbasin constitutes about 72 percent of the total industrial oxygen-demanding waste strength generated in Subregion 10. However, a relatively high level of waste treatment is maintained so that these industries contribute only 40 percent of the subregion's industrial organic waste load. During the critical summer season, the total organic waste strength produced is about 3.07 million PE, which are reduced to 645,070 PE by treatment. The principal waste source is the pulp and paper industry, which accounts for nearly 96 percent of the organic waste discharge.

Industrial waste sources are concentrated in the Aberdeen Service Area. An organic waste loading of about 645,070 PE is discharged to Grays Harbor. Three pulp and paper mills account for 620,200 PE of this waste load. The Washington Water Quality Standards call for secondary treatment and outfall improvments by September 30, 1970. A pulp and paper mill at Cosmopolis presently employs intermediate treatment, including lagoons and aeration. An average reduction of about 90 percent of the oxygen-demanding waste strength is accomplished so that about 192,000 PE are released to Grays Harbor. The Washington Water Quality Standards require that the facilities be upgraded to secondary treatment and that outfall facilities be provided by September

30, 1970. A paper company at Grays Harbor contributes an organic loading of about 24,000 PE to Grays Harbor without treatment. Primary treatment facilities are to be provided by September 30, 1970. Several lumber and wood products and food products plants are responsible for a waste loading of about 24,330 PE. In general, no treatment of wastes is provided before discharge to Grays Harbor. Near the service area, food products plants at Westport and Markham contribute a waste loading of about 5,380 PE to Grays Harbor.

The waste loading discharged by industries in the Chehalis-Centralia Service Area is relatively small. However, several industries in the area dispose of wastes to the municipal systems. Two farms near Centralia are the largest waste producers. One farm utilizes land disposal techniques to dispose of their wastes, and the other practices crop irrigation with their waste waters, resulting in little direct discharge to streams. Several sand-and-gravel and mining operations in the area are a source of sediment and inorganic materials.

The only other waste sources are several seafood plants in the Raymond and Ilwaco areas and plywood mills scattered throughout the subbasin. The waste loading contributed to waterways by these industries is relatively minor.

Rural-Domestic

Approximately 198,950 persons, or 47 percent of the population of the subregion are served by individual sewage disposal systems. Table 131 summarizes by subbasin the population and the percent of subbasin and subregional population served by individual systems. In general, septic tanks and some type of subsurface drainage are used for waste disposal. The actual waste load reaching waterways from rural-domestic sources is not considered to be large.

Table 131 - Summary of Population Served by Individual Waste Disposal Facilities, Subregion 10[1/]

Subbasin	Population Served Thousands	Percent of Subregion Population	Percent of Subbasin Population
Rogue	51.1	12.0	44.8
Umpqua	58.2	13.7	47.5
Other Oregon Coastal Areas	42.6	9.9	53.1
Washington Coastal	47.0	11.0	43.2
Total	198.9	46.6	

1/ Derived as a residual from FPCA Municipal and Industrial Waste Inventory, Coastal Subregion, 1965.

Irrigation

Irrigation in the Coastal Subregion is not extensive. A total of 181,000 acres, or one percent of the total land area, is presently irrigated. The annual diversion for irrigation is 600,000 acre-feet, of which approximately 261,000 acre-feet are returned to waterways as irrigation return flows.

The largest concentrations of irrigated acreage are in the interior areas of the Rogue and Umpqua River valleys. Most other irrigation has been on an individual farm basis and is practiced mainly on valley lands bordering major streams.

Irrigation diversions and return flows are not considered to be a major pollution source in most areas at the present level of development. The high annual precipitation in most of the subregion has largely removed easily dissolved constituents that would be leached by irrigation waters.

However, irrigation diversions and return flows are a major pollution source on Bear Creek and Applegate River. They are also becoming increasingly important in Ewona Creek and Little Butte Creek, both of which are in the Rogue Subbasin.

Agricultural Animals

Agricultural animal wastes are a significant source of pollution in the subregion. The animal population produces an estimated waste load equivalent to that from a population of 1.4 million persons. It is estimated that about five percent (70,000 PE) reaches streams through feedlot and pasture runoff.

Several streams in the areas of high cattle densities have exhibited high bacterial counts after a rainfall as a result of the runoff of animal wastes. This condition has been particularly notable on the Applegate, Wilson, Chehalis, and lower Coquille Rivers.

Other Land Uses

Other land use and management practices are not considered to be a major pollution source in the subregion. However, logging, logging road construction, and dam and highway construction are periodically important sources of high sediment loads. This problem is particularly critical in this subregion since many coastal streams serve as spawning and rearing areas for the anadromous fishery.

The generalized sediment yield ranges from 0.02 acre-foot per square mile per year in the upper reaches of the Rogue River basin to about 0.5 acre-foot per square mile per year, mostly in the agricultural areas, with about 80 percent of the areas lying in the 0.1 to 0.2 range. Sediment production is generally low. There are few, if any, areas where extensive bank or gully erosion is occurring. This may be attributable to the quick recovery of vegetation, relatively thin soils, and the coarse texture of alluvial deposits which prevent substantial downcutting. However, high turbidities and sedimentation are encountered during periods of high runoff below major logging, placer mining, and gravel-washing operations. In addition, streams draining the Olympic Mountains can carry heavy loads of glacial flour. The highest sediment yields on the coast have followed major forest fires.

Navigation and Dredging

The most important wastes from ships result from oil spills and bilge waters pumped while in transit, which contain oil and other petroleum products.

Dredging is normally carried out in the estuarine areas where sediment and waste products build up to block navigable waters. Dredging introduces quantities of suspended material to the local water prism. In bottom areas where debris and sludge beds have built up from pulp and paper waste discharges--such as in Coos and Yaquina Bays and Grays Harbor--dredging frees large quantities of oxygen-demanding organics in the water and may release toxic products of decomposition.

Present Water Quality

The water quality of the subregion is monitored by the Oregon State Department of Environmental Quality and the Washington Water Pollution Control Commission in cooperation with the Geological Survey. Nearly all streams entering marine waters and numerous tributaries are sampled on a regular basis. The Oregon State Department of Environmental Quality maintains quality stations for most important marine and estuarial waters of the Oregon Coast. In addition, many estuaries on the Washington and Oregon Coasts have been the subject of short-term water quality surveys. Table 132 summarizes annual mean and extreme values for selected water quality parameters.

In general, the waters of the subregion are of excellent quality and are suitable for all uses. The most commonly encountered problems include high coliform bacterial counts, high temperatures, and high nutrient levels. A few instances of low dissolved oxygen are found, and high turbidities and sedimentation are encountered during some periods of the year. Water quality deterioration from toxic materials has not been documented, although phenolics associated with plywood production and sulfites associated with pulp and paper production are discharged to subregional waters.

Fresh Waters

High dissolved oxygen concentrations exist throughout the lengths of most streams. The dissolved oxygen levels average about 10 mg/l for all streams. However, several localized areas exhibit dissolved oxygen depressions. In the Chehalis River downstream from the City of Chehalis, dissolved oxygen levels range between 0 and 3mg/l during the summer. Depressed oxygen levels occur in several reaches of Bear Creek and the South Umpqua River during low-flow periods. Even so, the minimum oxygen concentrations are seldom below 6.5mg/l. In addition, dissolved oxygen concentrations of 4.0 and 5.4 mg/l have been reported in the lower reaches of the Yaquina and Coquille Rivers, respectively, during September.

With the exceptions of the Chehalis River and a tributary (the Cloquallum River), the Washington Coastal streams are of excellent bacterial quality. The Chehalis and Cloquallum Rivers have exhibited coliform densities as high as 24,000 organisms/100 ml, and the densities average above 1,000 organisms/100 ml (usually considered the limit for safe water-contact recreation).

Table 132 - Summary of Water Quality Data, Subregion 10

	River Mile	D. O. (mg/1)	T (°C)	Coliform MPN/ 100ml	pH	Color (PT-CO Units)	Hard. (mg/1)	Turb. (JTU)	TDS (mg/1)	Ortho PO_4 (mg/1)	NO_3-N (mg/1)
Rogue River near Prospect, Ore.	164.1										
Mean		11.1	8.3	420	-	-	-	4		0.11	0.03
Minimum		9.0	2.0	6	-	-	-	0		0.01	[illegible]
Maximum		13.0	14.0	6,200	-	-	-	12		0.21	0.31
No. of Samples		31	32	30	-	-	-	33		33	33
Bear Creek at Ashland, Ore.	126.8-22.4				-	-	-				
Mean		10.3	12.4	3,400	-	-	-	23		0.24	0.16
Minimum		6.8	1.0	45	-	-	-	12		0.10	0.01
Maximum		13.5	25.0	7,000	-	-	-	45		0.36	0.40
No. of Samples		39	39	37	-	-	-	5		5	5
Bear Creek near Central Point, Ore.	126.8-3.8				-	-	-				
Mean		10.4	14.6	31,000	-	-	-	35		0.54	0.32
Minimum		7.0	4.0	62	-	-	-	5		0.01	0.01
Maximum		13.8	31.0	>70,000	-	-	-	90		1.30	1.33
No. of Samples		33	34	32	-	-	-	22		33	33
Rogue River at Grants Pass, Ore.	101.3				-	-	-				
Mean		11.2	13.3	3,700	-	-	-	5		0.22	0.15
Minimum		9.1	2.0	130	-	-	-	1		0.19	0.01
Maximum		13.5	25.0	24,000	-	-	-	6		0.31	0.33
No. of Samples		32	33	29	-	-	-	5		5	5
Rogue River at Merlin, Ore.	86.0				-	-	-				
Mean		11.1	13.7	4,670	-	-	-	5		0.16	0.08
Minimum		9.1	4.0	5	-	-	-	0		0.01	0.01
Maximum		12.7	25.5	77,000	-	-	-	27		0.27	0.85
No. of Samples		32	33	32	-	-	-	33		34	34
S. Fork Coquille R. near Powers, Ore.	27.2				-	-	-				
Mean		11.1	13.4	2,996	-	-	-	4		0.05	0.03
Minimum		8.7	3.0	23	-	-	-	0		0.00	0.00
Maximum		14.1	26.0	7,000	-	-	-	35		0.22	0.12
No. of Samples		21	22	21	-	-	-	21		22	22
South Umpqua River at Days Creek, Ore.	168.9				-	-	-				
Mean		10.3	15.5	189	-	-	-	12		0.10	0.04
Minimum		8.6	4.0	5	-	-	-	0		0.00	0.00
Maximum		12.7	28.0	700	-	-	-	76		2.09	0.14
No. of Samples		36	37	36	-	-	-	39		37	31
Cow Creek below Riddle, Ore.	158.9-1.3				-	-	-				
Mean		10.5	16.4	5,142	-	-	-	2		0.12	0.02
Minimum		8.4	5.0	60	-	-	-	1		0.01	0.01
Maximum		12.6	27.5	24,000	-	-	-	4		0.19	0.05
No. of Samples		20	21	20	-	-	-	4		4	4
South Umpqua River at Melrose Road	118.8				-	-	-				
Mean		10.3	16.3	12,634	-	-	-	12		0.21	0.09
Minimum		6.3	5.0	450	-	-	-	0		0.01	0.01
Maximum		12.3	27.0	70,000	-	-	-	80		0.73	0.44
No. of Samples		36	36	36	-	-	-	37		39	39
North Umpqua River at Lone Rock Bridge	111.7-31.1				-	-	-				
Mean		11.1	12.6	84	-	-	-	8		0.08	0.04
Minimum		9.2	4.0	6	-	-	-	0		0.00	0.00
Maximum		13.0	20.0	240	-	-	-	61		0.40	0.12
No. of Samples		36	37	35	-	-	-	39		39	39
Umpqua River at Elkton, Ore.	48.6				-	-	-				
Mean		10.2	16.6	970	-	-	-	12		0.05	0.02
Minimum		8.3	5.0	6	-	-	-	0		0.00	0.01
Maximum		12.5	26.0	7,000	-	-	-	85		0.38	0.04
No. of Samples		36	37	35	-	-	-	39		39	39
Siuslaw River at Mapleton, Ore.	20.5-21.0				-	-	-				
Mean		9.6	13.8	610	-	-	-	3		0.03	0.10
Minimum		5.2	1.0	130	-	-	-	0		0.01	0.01
Maximum		13.2	23.0	2,400	-	-	-	20		0.11	0.35
No. of Samples		26	28	26	-	-	-	24		22	22
Siletz River near Siletz, Ore.	30.9-31.5				-	-	-				
Mean		10.4	13.1	350	-	-	-	3		0.02	0.12
Minimum		8.1	2.0	23	-	-	-	0		0.01	0.01
Maximum		13.2	20.0	2,400	-	-	-	10		0.12	0.40
No. of Samples											
Nehalem River Station 1130	7.3				-	-	-				
Mean		10.9	11.8	290	-	-	-	5		0.07	0.14
Minimum		8.0	1.5	13	-	-	-	0		0.01	0.00
Maximum		13.4	21.0	700	-	-	-	20		0.65	0.58
No. of Samples		24	24	23	-	-	-	24		23	24
Wilson River Station 1165	8.5				-	-	-				
Mean		12.0	12.1	140	-	-	-	3		0.04	0.05
Minimum		7.3	5.0	5	-	-	-	0		0.01	0.01
Maximum		12.9	20.0	700	-	-	-	20		0.17	0.14
No. of Samples		25	27	25	-	-	-	24		24	24

Table 132 (Continued)

	River Mile	D.O. (mg/1)	T (°C)	Coliform MPN/ 100ml	pH	Color (PT-CO Units)	Hard. (mg/1)	Turb. (JTU)	TDS (mg/1)	Ortho PO_4 (mg/1)	NO_3-N (mg/1)
Bear River near Naselle, Wash.											
Mean		10.3	10.6	446	6.9	-	14	-	43	-	0.4
Minimum		8.8	5.9	0	6.3	5	8	-	34	-	0.1
Maximum		11.7	15.5	4,600	7.2	20	18	-	52	-	0.6
No. of Samples											
Naselle River near Naselle, Wash.											
Mean		11.2	11.8	180	7.2	-	16	-	41	-	0.8
Minimum		9.1	5.1	0	6.7	5	11	-	37	-	0.1
Maximum		14.0	18.9	930	7.6	10	20	-	48	-	1.7
No. of Samples											
Willapa River at Willapa, Wash.											
Mean		10.5	12.6	676	7.0	-	17	-	48	-	1.2
Minimum		8.1	5.3	36	6.4	5	10	-	35	-	0.1
Maximum		13.2	20.8	4,600	7.5	15	23	-	64	-	3.2
No. of Samples											
Chehalis River near Doty, Wash.											
Mean		10.9	10.8	563	7.1	-	20	-	50	0.03	0.6
Minimum		7.6	2.0	0	6.7	5	14	0	39	0.00	0.1
Maximum		13.8	22.6	4,600	7.6	20	27	50	62	0.17	1.4
No. of Samples											
Chehalis River at Porter, Wash.											
Mean		10.4	12.5	1,213	7.1	-	23	-	56	0.06	0.9
Minimum		7.2	3.3	0	6.7	0	12	0	35	0.00	0.1
Maximum		12.8	23.4	24,000	7.6	30	36	40	80	0.14	2.0
No. of Samples											
Cloquallum River at Elma, Wash.											
Mean		10.5	10.9	2,840	7.1	-	22	-	51	0.04	1.4
Minimum		4.8	4.9	36	6.6	5	12	0	38	0.00	0.5
Maximum		12.5	20.2	24,000	7.8	30	29	25	67	0.13	3.7
No. of Samples											
Satsop River near Satsop, Wash.											
Mean		10.9	11.8	145	7.2	-	21	-	46	0.02	0.4
Minimum		5.3	5.1	0	6.8	0	12	0	33	0.00	0.1
Maximum		12.8	20.1	2,400	7.6	20	28	180	55	0.04	1.2
No. of Samples											
Wynoochee River near Montesano, Wash.											
Mean		10.8	11.2	113	7.2	-	23	-	41	0.01	0.4
Minimum		6.9	4.8	0	6.8	0	14	0	28	0.00	0.0
Maximum		13.8	22.3	930	7.7	20	42	250	58	0.03	1.3
No. of Samples											
Humptulips River near Humptulips, Wash.											
Mean		10.9	10.8	78	7.2	-	21	-	41	0.01	0.3
Minimum		9.0	4.9	0	6.7	0	13	0	29	0.00	0.0
Maximum		12.9	22.0	430	7.6	20	27	150	52	0.03	2.2
No. of Samples											
Quinault River at Quinault Lake, Wash.											
Mean		10.6	10.0	20	7.1	-	25	-	38	0.01	0.2
Minimum		9.2	5.6	0	6.8	0	22	0	32	0.00	0.0
Maximum		13.0	17.8	230	7.4	10	42	15	51	0.06	0.5
No. of Samples											
Queets River at Queets, Wash.											
Mean		11.1	10.3	86	7.1	-	23	-	40	0.01	0.3
Minimum		9.2	4.2	0	6.4	0	10	0	26	0.00	0.0
Maximum		12.9	20.0	430	7.5	80	30	400	49	0.04	1.4
No. of Samples											
Hoh River near Forks, Wash.											
Mean		11.3	8.9	87	7.3	-	29	-	46	0.01	0.2
Minimum		10.2	4.0	0	6.6	0	10	0	28	0.00	0.0
Maximum		13.2	17.0	930	7.6	25	35	300	53	0.05	0.6
No. of Samples											
Soleduck River near Fairholm, Wash.											
Mean		11.3	9.4	28	7.5	-	31	-	46	0.01	0.1
Minimum		9.2	3.4	0	7.0	0	16	0	27	0.00	0.0
Maximum		13.7	18.8	360	7.9	15	43	35	58	0.04	0.3
No. of Samples											

1/ FWDCA STORET, 1968

High coliform counts are found in reaches of many Oregon Coast streams. These high bacterial densities have great significance when the extensive recreational water contact in the Coastal Subregion is considered. The major problem areas have been the Rogue River, Bear Creek, South Umpqua River, Cow Creek, South Fork Coquille River, Nestucca River, Coquille River below Bandon, Umpqua River below Reedsport, Columbia River below Astoria, and several streams draining into Tillamook Bay--including the Wilson, Trask, and Tillamook Rivers. The sources of coliform organisms are difficult to identify. In the lower reaches of the Umpqua, Coquille, South Umpqua, and Columbia Rivers, the high densities are probably the result of inadequately treated municipal wastes. In the Rogue, South Fork Coquille, and Nestucca Rivers, Bear Creek, and the Tillamook area streams, the problem possibly results from a combination of domestic, agricultural, cheese and creamery, and slaughterhouse wastes.

Maintaining adequate water temperature levels is a significant problem in the Coastal Subregion. Elevated temperatures have detrimental effects on salmonid fisheries, which make up a significant portion of the economic resource of the Coastal area. The major areas of concern have been the Rogue, Umpqua, and Chehalis Rivers and tributaries. Temperatures in these streams average above 70° F. (21° C.) during the months of July and August, and maximums range from over 80° F. to 93° F. (27° to 34° C.). Figures 99 and 100 present temperature profiles for the Rogue and Umpqua Rivers for the month of July.

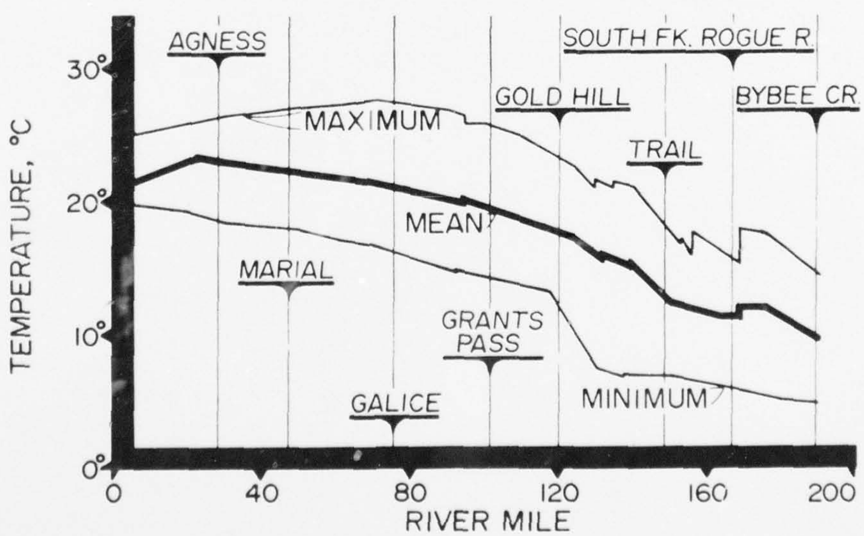


FIGURE 99. Temperature Profile (Generalized), Rogue River

The highest sediment concentrations observed in some streams since 1963 were 2,360 mg/l in the Wynoochee River; 1,860 mg/l in Schooner Creek; 1,450 mg/l in the Yachats River; 1,260 mg/l in the Siletz River; 949 mg/l in the Satsop River; and 943 mg/l in the Newaukum River. These high sediment levels have generally occurred as a result of a high runoff during the month of December. Also, in the South Fork of the Necanicum River below logging operations, maximum instantaneous sediment concentrations in excess of 70,000 mg/l have been reported.

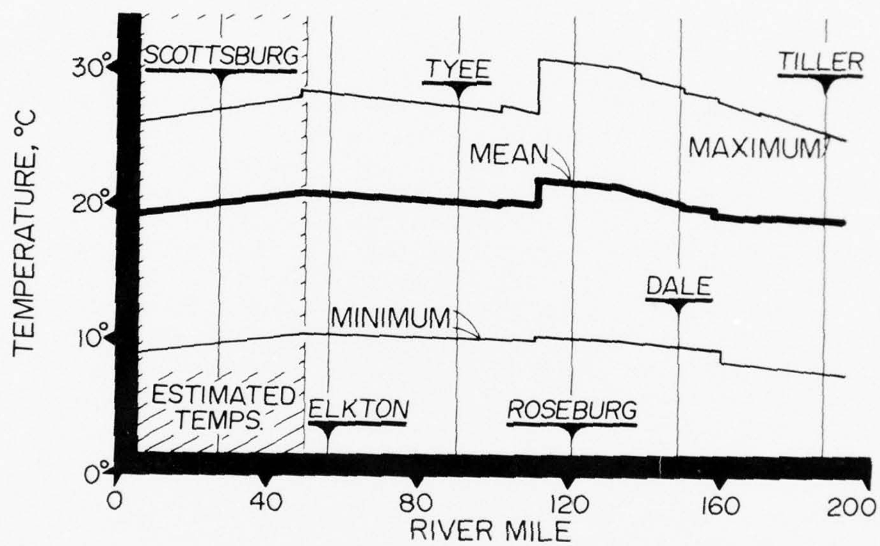


FIGURE 100. Temperature Profile (Generalized), Umpqua River

Most of the streams in the Coastal Subregion originate in the mountains of the Coast Range geologic province and drain into the Pacific Ocean. They are of excellent mineral character. Some slight differences in chemical composition are apparent among streams draining the northern, central, and southern parts of the subregion.

In the northern part, the streams originate in the high elevations of the Olympic Mountains and many are glacier-fed. They contain calcium bicarbonate type waters which are low in dissolved solids and very soft. Dissolved solids concentrations range from 30 to 60 mg/l and average less than 50 mg/l. The hardness averages less than 30 mg/l. The streams are sometimes very turbid with glacial flour.

The streams draining the Coast Range in the Central part of the subregion are also very low in dissolved solids and are very soft. Calcium and bicarbonate are usually the predominant ions, but sodium and chloride make up a larger percentage of the total dissolved ions than in the streams draining the Olympic Mountains. The greater percentage of sodium and chloride in these streams most likely comes from oceanic aerosols. Windblown salt particles from the ocean are carried inland in fog or clouds. These particles form condensation nuclei for water droplets and are carried to earth again in the form of rain or snow, resulting in an increase in salt content in the coastal streams. Aerosols undoubtedly also affect streams draining the Olympic Mountains. However, the effect is apparently diluted because of the much greater runoff per square mile which occurs as a result of the extremely high precipitation in that area.

The Rogue River, located at the southern end of the subregion, originates in the high elevations of the Cascade Range, flows through a central valley section, and then cuts through the Klamath Mountains before emptying into the Pacific Ocean. The upper reaches of the Rogue River contain calcium-magnesium bicarbonate water with an average dissolved solids concentration of about 60 mg/l. There is some downstream increase in mineralization of the Rogue River as a result of inflows from Bear Creek and Applegate River, which are considerably more mineralized. The flow of these two streams is small in relation to the main stem, and influence on the chemical quality of the Rogue River is slight. The maximum reported dissolved solids concentration in the Rogue River at Merlin, below all major tributaries except the Illinois River, is 90 mg/l.

The Illinois River (a tributary of the Rogue River) and the South Fork Coquille River are considerably different in chemical character from all other streams in the subregion for which data are available. Both of these streams are magnesium bicarbonate waters. In the South Fork Coquille River, the percentage of magnesium ion is only slightly higher than that of calcium ion. In the Illinois River, magnesium averages 68 percent of the dissolved cations, while calcium accounts for only 24 percent. Both of these streams drain areas in the Klamath Mountains which are underlain by igneous and metamorphic rocks that contain large amounts of the magnesium-rich minerals pyroxene and olivine.

All of the waters of the subregion are of excellent mineral quality except in tide-affected reaches, and many could be used for most purposes with minimum treatment. Natural high turbidity and color are a problem at certain times of the year, especially in the streams which drain the Olympic Mountains. The lower reaches of most streams are affected by saltwater intrusion. In

many of the streams, the rise in elevation is very slight for long distances upstream. In the Siuslaw River, high chloride and sodium concentrations, indicative of saltwater intrusion (and too large to be attributed to aerosol intrusion), have been found as far as 20 miles upstream from the mouth.

Nutrient values at higher than desirable levels (0.075 mg/l--PO_4 as PO_4 and 0.30 mg/l--NO_3 as N) occur in several coastal streams. The Rogue River and two tributaries (Bear Creek and the Applegate River), the South Umpqua River and a tributary (Cow Creek), and the Chehalis River exhibit the highest nutrient concentrations. As a result, these streams are capable of supporting nuisance algal blooms. This condition is particularly acute during periods of low streamflow.

Marine and Estuarine Waters

The marine and estuarine waters of the subregion are of prime importance for recreation, as clam and oyster rearing areas, and for passage of anadromous fish. In several estuaries, discharges of untreated or inadequately treated domestic and industrial wastes and agricultural runoff have seriously degraded water quality. These estuaries include Coos Bay, Umpqua Bay, Yaquina Bay, Nehalem Bay, Tillamook Bay, and Grays Harbor.

Dissolved oxygen levels are generally satisfactory for fish passage in most marine waters; however, Coos Bay, Yaquina Bay, and Grays Harbor do exhibit oxygen depressions during certain periods of the year. In Coos Bay, oxygen levels of one to two mg/l have been reported during late summer and early fall. In Yaquina Bay and Coos Bay, depletion of water quality during the summer months is caused by the very low inflow into the bays and large waste loading. This flow is not large enough to allow flushing and, thus, a pool of water is trapped until high water flows force the water out. A periodic phenomenon in Grays Harbor which results from particular conditions of wind and current, referred to as upwelling, replaces bay water with low DO water which is forced up from great depths offshore. The DO content of the deeper waters may be as low as one to two mg/l. When upwelling occurs during the season of high temperatures and low streamflow, it reduces the estuary's ability to provide the needed oxygen resource and thereby intensifies the oxygen deficit.

In several areas of the Oregon Coast, discharges of untreated or inadequately treated domestic and industrial wastes and agricultural runoff have reached the point of causing a threat to health. These areas include Nehalem Bay, Tillamook Bay, Yaquina Bay, and Umpqua Bay. The most significant of these areas are Yaquina and

Tillamook Bays, where recently the Public Health Service "conditionally approved" oyster growing areas with the stipulation that action be taken to reduce coliform levels in the bays.

Toxic sulfite waste liquor effluents from pulp and paper mills and phenolics associated with plywood production have deteriorated water quality in Coos Bay, Yaquina Bay, and Grays Harbor. The discharges have caused unsightly and interfering floating materials as well as rendering some areas sterile for normal aquatic populations.

Summary of Problems

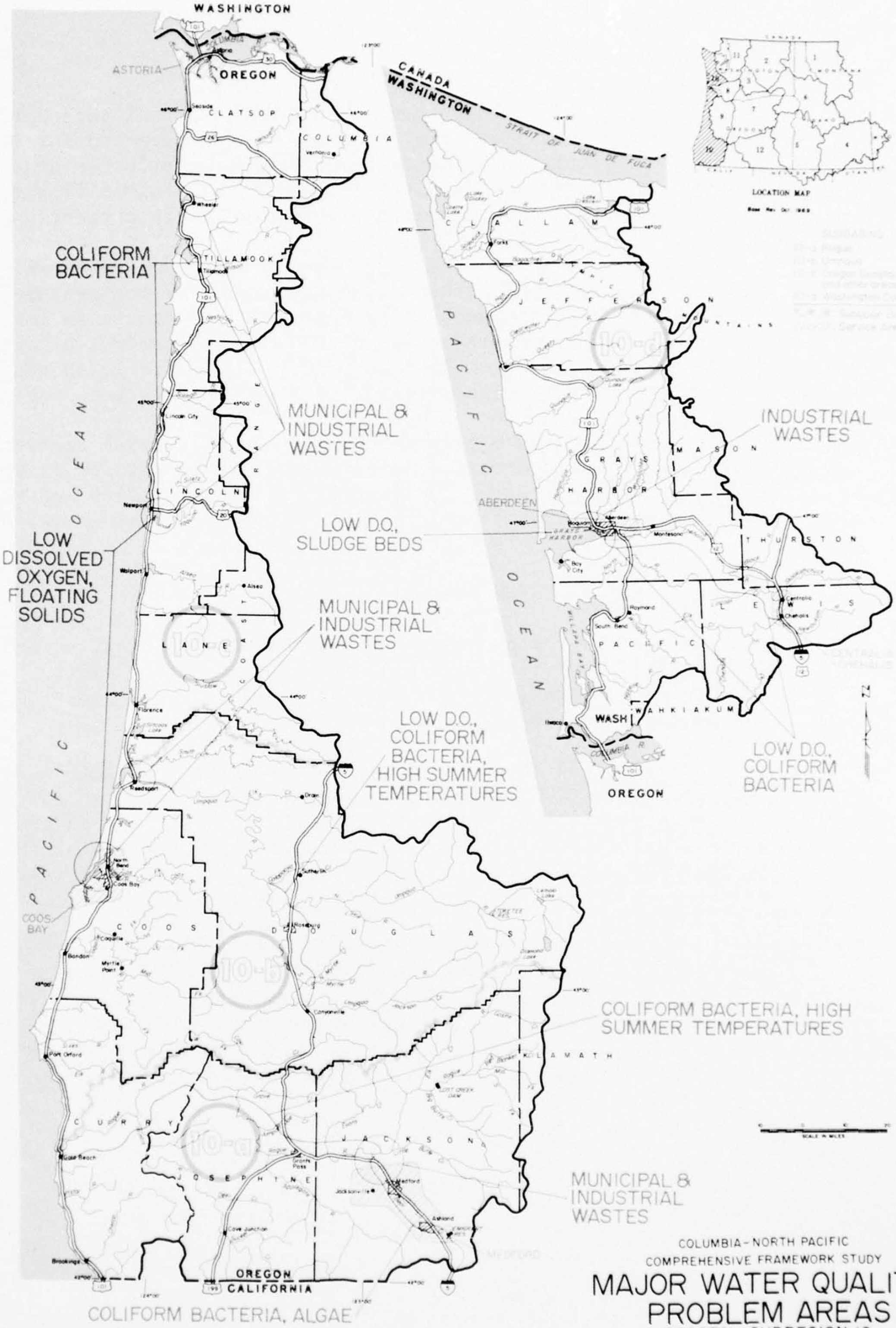
A graphical summary of water quality problem areas in Subregion 10 is presented in figure 101. In general, most serious water quality degradation is associated with inadequately treated municipal and industrial wastes in combination with low summertime streamflows.

The major estuaries showing water quality deterioration are Yaquina, Coos, and Tillamook Bays and Grays Harbor. Effluents from pulp and paper and plywood mills along Yaquina and Coos Bays cause problems from floating solids as well as oxygen depressions during the summer months when there is little net movement of water to the ocean. These conditions are a deterrent to aquatic life and the recreational potential of the bays. Grays Harbor suffers from periodic low dissolved oxygen levels and sludge accumulations. Pulp and paper mill wastes are the major source of the problems, although the upwelling of deep ocean waters which are low in oxygen is believed to contribute to the oxygen depression. Bacterial contamination from domestic sewage and livestock wastes has been identified by Federal authorities as a potential threat to shellfish in Yaquina and Tillamook Bays.

The major freshwater streams experiencing water quality problems are the Rogue River below Bear Creek, Bear Creek, the South Umpqua River, and the Chehalis River.

The entire length of the Rogue River below Bear Creek exhibits coliform densities greater than those desirable for safe water-contact recreation. In addition, temperatures in excess of 70° F. (21.1° C.) are evident at all sampling points during August and September. Fishery agencies have recommended storage to provide a minimum flow of 2,000 cfs in the Rogue to control water temperature for fishery enhancement.

Bear Creek, which receives municipal and industrial wastes from the Medford Service Area, irrigation return flows, and



COLUMBIA - NORTH PACIFIC
COMPREHENSIVE FRAMEWORK STUDY

MAJOR WATER QUALITY PROBLEM AREAS

COASTAL SUBREGION 10

1970

FIGURE 101

agricultural waste waters, becomes an aesthetic nuisance during summer months when flows are low and water is diverted for irrigation. Nutrients from these sources promote extensive aquatic growths, and bacterial densities are high. A minimum flow of 75 cfs for water quality control in Bear Creek is currently needed.

Water quality in the South Umpqua River during low-flow periods does not meet either dissolved oxygen or temperature requirements for anadromous fish migration. There is an immediate need for a minimum average flow of 190 cfs for control of dissolved oxygen in the summer months, and a minimum flow of 1,200 cfs has been recommended by fishery agencies for temperature enhancement.

Low dissolved oxygen levels and high bacterial concentrations occur in the Chehalis River during the summer low-flow period. This poor water quality affects the migration and rearing of anadromous fish and participation in recreational activities.

FUTURE WATER QUALITY MANAGEMENT NEEDS

Based on the projected economic development of the subregion, the population is expected to increase from 425,800 in 1965 to 735,900 in 2020--an increase of 73 percent, compared with 121 percent for the region.

Figure 102 shows the projected subbasin populations for the years 1980, 2000, and 2020. The projected subbasin and service area populations for municipal and rural categories are presented in table 133. By 2020, nearly three-fourths of the subregional population will be located in the five major service areas.

The future economic growth will continue to be based on the abundant forest resources. The pulp and paper industry is not expected to experience as rapid a growth rate as the food products industry, but will remain the largest producer of organic waste in the subregion. The lumber and wood products industry is expected to show a decline during this period.

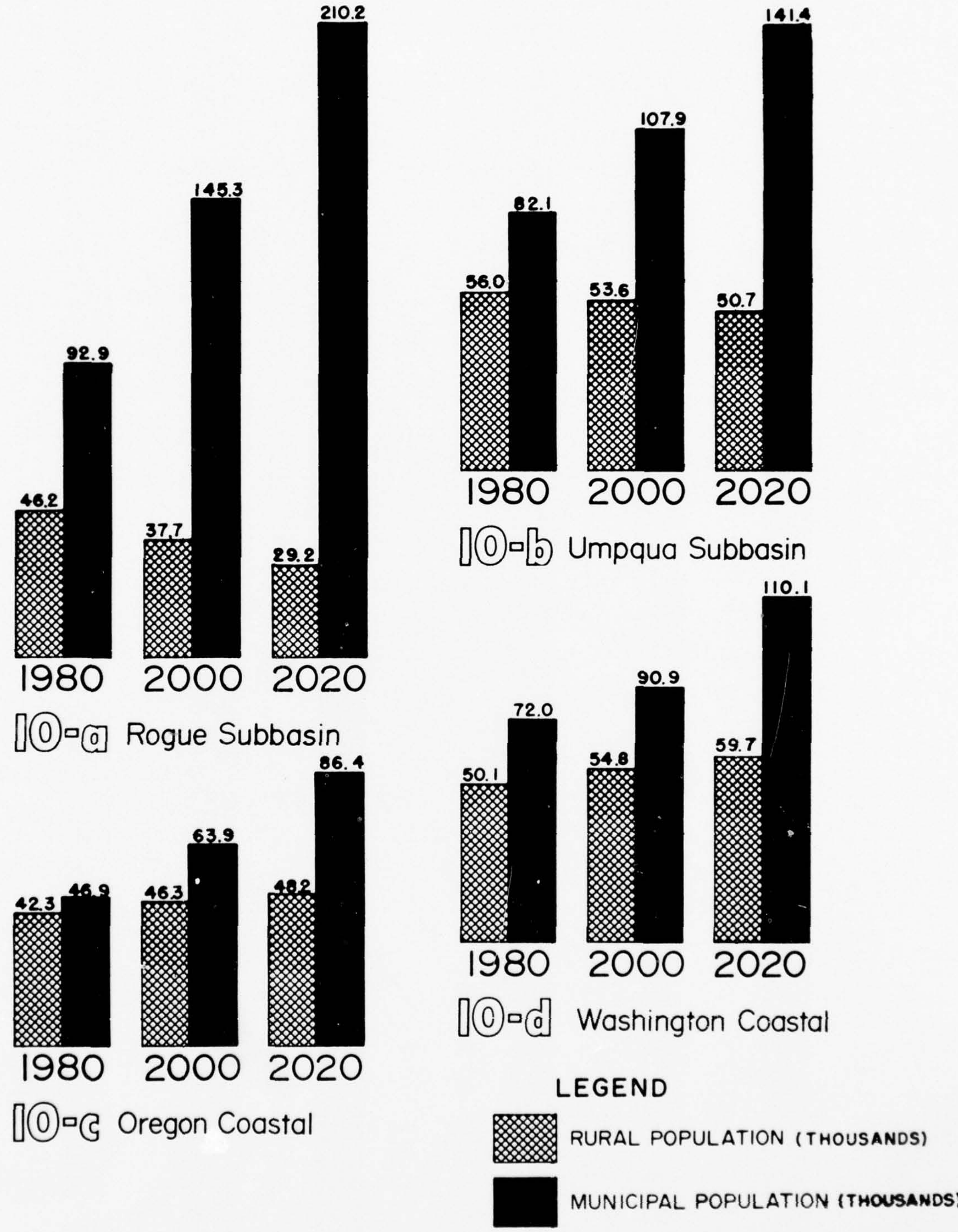


FIGURE 102. Projected Population, Subregion 10

Table 133 - Projected Population, Subregion 10[1/]

	1980	2000 (Thousands)	2020
Rogue Subbasin	139.1	183.0	239.4
Medford Service Area	84.2	125.8	180.4
Municipal	66.6	117.0	180.4
Rural	17.6	8.8	--
Other	54.9	57.2	59.0
Municipal	26.3	28.3	29.8
Rural	28.6	28.9	29.2
Subtotal	139.1	183.0	239.4
Municipal	92.9	145.3	210.2
Rural	46.2	37.7	29.2
Umpqua Subbasin	138.1	161.5	192.1
Coos Bay Service Area	40.7	60.6	90.3
Municipal	34.7	57.6	90.3
Rural	6.0	3.0	--
Other	97.4	100.9	101.8
Municipal	47.4	50.3	51.1
Rural	50.0	50.6	50.7
Subtotal	138.1	161.5	192.1
Municipal	82.1	107.9	141.4
Rural	56.0	53.6	50.7
Other Oregon Coastal Areas Subbasin	89.2	110.2	134.6
Astoria Service Area	21.9	29.9	41.6
Municipal	18.1	28.0	41.6
Rural	3.8	1.9	--
Other	67.3	80.3	93.0
Municipal	28.8	35.9	44.8
Rural	38.5	44.4	48.2
Subtotal	89.2	110.2	134.6
Municipal	46.9	63.9	86.4
Rural	42.3	46.3	48.2
Washington Coastal Subbasin	122.1	145.7	169.8
Aberdeen Service Area	39.0	45.9	52.5
Municipal	37.3	45.0	52.5
Rural	1.7	0.9	--
Chehalis-Centralia Service Area	18.8	21.8	25.1
Municipal	16.8	20.8	25.1
Rural	2.0	1.0	--
Other	64.3	78.0	92.2
Municipal	17.9	25.1	32.5
Rural	46.4	52.9	59.7
Subtotal	122.1	145.7	169.8
Municipal	72.0	90.9	110.1
Rural	50.1	54.8	59.7
Total Subregion	488.5	600.4	735.9
Municipal	293.9	409.0	548.1
Rural	194.6	191.4	187.8

1/ Derived from Economic Base and Projections, Appendix VII, Columbia-North Pacific Framework Study, January 1971, and from North Pacific Division Corps of Engineers data.

Differences between totals in this table and source are due to differences in subregion boundaries. The source is based on economic boundaries and this table is based on hydrologic boundaries. The municipal population is defined as that population discharging wastes to a municipal sewerage system. The rural population is defined as the residual.

Future Waste Production

Municipal

The projected municipal raw waste production for the subregion is presented in table 134. The population served by municipal waste collection and treatment systems is expected to increase from 53 percent in 1965 to 74 percent by the year 2020. It has been assumed that the entire populations of the five major service areas will be served by municipal sewerage collections systems by that time. These service areas are expected to account for 71 percent of the raw municipal waste production in 2020.

Table 134 - Projected Municipal Raw Organic Waste Production Subregion 10 1/

	1970 2/	1980	2000	2020
		(1,000's P.E.)		
Rogue Subbasin	90.9	116.1	181.6	262.6
Medford Service Area	66.2	83.2	146.2	225.4
Other	24.7	32.9	35.4	37.2
Umpqua Subbasin	88.9	102.6	134.9	176.8
Coos Bay Service Area	33.0	43.4	72.0	112.9
Other	55.9	59.2	62.9	63.9
Other Oregon Coastal Areas Subbasin	50.9	58.6	81.1	108.0
Astoria Service Area	17.5	22.6	35.0	52.0
Other	33.4	36.0	46.1	56.0
Washington Coastal Subbasin	81.6	90.0	113.6	137.6
Aberdeen Service Area	43.0	46.6	56.2	65.6
Chehalis-Centralia Service Area	18.9	21.0	26.0	31.4
Other	19.7	22.4	31.4	40.6
Total Subregion	312.3	367.3	511.2	685.0

1/ A factor of 1.25 was applied to the municipal population components to account for the effects of small commercial establishments and other urban activities which add to municipal waste loads.

2/ Interpolated from 1965 data and 1980 projections.

Industrial

Projected raw organic waste loadings for the major industrial categories are presented in table 135 for the years 1980, 2000, and 2020. By the end of the projection period, it is expected that industries will account for nearly 92 percent of the total organic waste production for the entire subregion. The pulp and paper industry will continue to be the largest source of organic wastes, contributing approximately 95 percent of the total industrial waste production.

Table 135 - Projected Industrial Raw Organic Waste Production Subregion 10 1/ (5) (17)

	1970	1980	2000	2020
		(1,000's P.E.)		
Pulp and Paper	5,194.3	7,510.0	9,020.0	9,800.0
Lumber and Wood Products	70.1	61.0	57.0	54.0
Food Products	169.2	228.0	314.0	436.0
Total	5,433.6	7,799.0	9,391.0	10,290.0

1/ Per data from FPCA Municipal and Industrial Waste Inventory, Coastal Subregion, 1965.

In general, increases in waste production are expected to occur at existing operations for most industries. The lumber and wood products industry, however, is expected to decrease somewhat by 2020.

Rural-Domestic

The projected rural-domestic waste production is summarized in table 136. The rural-domestic waste production was assumed to be equal to the rural component shown in table 133. The general trend of rural population in the region is downward; however, this segment of the population is expected to increase slightly in the Washington Coastal and other Oregon Coastal Areas Subbasins.

Table 136 - Projected Rural Domestic Raw Organic Waste Production
Subregion 10

	1970 1/	1980	2000	2020
		(1,000's P.E.)		
Rogue Subbasin	49.7	46.2	37.7	29.2
Umpqua Subbasin	57.1	56.0	53.6	50.7
Other Oregon Coastal Areas Subbasin	42.1	42.3	46.3	48.2
Washington Coastal Subbasin	48.2	50.1	53.8	59.7
Total Subregion	197.1	194.6	191.4	187.8

1/ Interpolated from 1965 data and 1980 projections.

Irrigation

About 181,000 acres are presently irrigated in the subregion, requiring an annual diversion rate of 3.3 acre-feet per acre. Irrigation acreage is projected to increase to 280,000 acres by 1980; 290,000 acres by 2000; and 330,000 acres by 2020. More efficient use and application of water are expected to reduce the diversion rate.

Agricultural Animals

Farm animals produce large amounts of waste; however, most of the waste is disposed of on the land. The raw organic waste production by the livestock population is expected to be equivalent to that from a population of 1,400,000 in 1980; 1,800,000 in 2000; and 2,400,000 in 2020. It is projected that a greater percentage of the cattle will be on feedlots by the year 2020, as compared with present practices. Dairies, feedlots, and other animal concentrations along streams cause accelerated erosion, as well as intensifying the potential coliform bacteria, nutrients, and biochemical oxygen demand in the water.

Other Land Uses

Projections of land use are shown in table 137.

Table 137 - Present and Projected Land Use, Subregion 10 (5) (8)

	1966	1980	2000	2020
		Thousands of Acres		
Land Use				
Cropland	585	472	421	370
Irrigated	175	270	284	316
Nonirrigated	410	202	137	54
Forest	13,829	13,795	13,747	13,700
Range 1/	168	160	150	140
Other 2/	472	587	676	764
Total	15,054	15,014	14,994	14,974

1/ Does not include forest range.
2/ Includes barren land, roads, railroads, small water areas, urban and industrial areas, farmsteads, etc.

The projections show a decrease in land area for crop, range and forest lands by the year 2020. Increased use of fertilizers on the crop and pasture lands will represent a potential source of nutrients.

Higher turbidities and sedimentation can be expected from increased timber harvest from the forest and woodlands. Placer mining and gravel-washing operations will also increase the sedimentation problem.

Recreation

The projected raw waste production by recreation activities are summarized in table 138.

Table 138 - Projected Recreation Wastes, Subregion 10 1/

Year	Population Equivalents
1970	253,000
1980	344,000
2000	633,000
2020	1,166,000

1/ Bureau of Outdoor Recreation and U.S.D.A. Forest Service Projections for total man recreation days (TMRD).

In the determination of wastes from recreation activities, the population equivalent is based on the total annual recreation days. The above values represent the daily raw waste production for a typical summer weekend.

Other Factors Influencing Quality

Navigation influences water quality. The pumping of bilges and other discharges from ships degrades water quality. Bilges almost always contain oils and other petroleum products.

Dredging is necessary in the estuarine areas where sediments and waste products build up and block navigable waters. The removal of this material alone causes turbidity and releases large quantities of oxygen-demanding organics and also toxic products of decomposition. The disposal of the dredged material creates additional problems.

There is always the danger of spills of oils and other hazardous materials which could cause an ecological disaster.

During summer months when natural flows are the lowest and water is also being diverted for irrigation, nutrients from sewage effluent and irrigation return flows promote extensive water growths.

Quality Goals

The water quality goals represent the levels of water quality required to fully support the maximum water uses. In managing the subregion's water, the primary purpose is to protect and enhance the quality and value of the water resources and to establish programs for the prevention, control, and abatement of water pollution to allow maximum use of the resource for all beneficial purposes.

Water quality standards were adopted by the states of Oregon and Washington after holding public hearings, and the Secretary of the Interior has approved the standards, thereby making them Federal standards as well. The states have also developed water quality standards for intrastate waters which are consistent with the interstate standards. These water quality standards are the basis for the water quality goals in this study.

In establishing the water quality standards, the use of each body of water was determined, and criteria were set to protect these uses through quality levels which must be maintained. In addition, the standards incorporate an anti-degradation provision

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by requiring that waters whose existing quality is better than the established standards be maintained at the existing higher quality level. This means that the highest and best practicable treatment under existing technology should be applied to all waste discharges. The common parameters generally used are dissolved oxygen concentrations, temperature, turbidity, and coliform density.

The water quality standards are summarized in table 139.

Table 139 - Water Classification and Criteria
Subregion 10 (Washington)

Water Quality Parameters	Class AA Extraordinary	Class A Excellent	Class B Good
Coliform	50 MPN	240 MPN	1,000 MPN
Dissolved oxygen	9.5 mg/1	8.0 mg/1	6.5 mg/1
Temperature 1/	60° F.	65° F.	70° F.
pH	6.5-8.5	6.5-8.5	6.5-8.5
Turbidity	5 JTU	5 JTU	10 JTU
Aesthetic values	-- Shall not be impaired by the presence of materials or their effects, excluding those of natural origin, which offend the sense of sight, smell, touch, or taste.		

Water Criteria - Oregon

Coliform	70-240/100 ml
Dissolved oxygen	6 mg/1
Temperature	64° F. with 2° F. rise below 66° F.
pH	6.5-8.5
Turbidity	5 JTU

1/ For all classes, the permissible increase in temperature over natural conditions is less than 1.8° F.

The above criteria are not inclusive, and the water quality standards should be consulted for specific information. Copies of the water quality standards are available upon request from the Oregon Department of Environmental Quality and the Washington Water Pollution Control Commission.

MEANS TO SATISFY DEMANDS

In general, the waters of Subregion 10 are of excellent quality and suitable for all uses. The most serious water quality degradation is associated with estuarial pollution and with inadequately treated municipal and industrial wastes in combination with low summertime flows. Insuring water quality to adequately serve the river systems' functions will require a coordinated program of waste reduction, flow regulation, application of waste-controlling techniques, and development of a system of cooperative management of the water resources.

Waste Treatment

Future Waste Discharges

Complete waste collection and adequate waste treatment facilities are the primary means for achieving desired water quality goals in the subregion. Based on the treatment levels discussed in the Regional Summary and raw waste projections presented earlier, the projected municipal waste loadings to be discharged to the waters of each subbasin are shown in table 140. The industrial waste loadings for major industrial categories are presented in table 141. The total municipal and organic waste loading is expected to be: 1,225.1 PE in 1980; 990.2 PE in 2000; and 1,097.5 PE in 2020. The pulp and paper industry is expected to be the largest industrial discharger of organic waste materials.

Table 140 - Projected Municipal Organic Waste Discharges
Subregion 10

	1980	2000	2020
		(1,000's P.E.)	
Rogue Subbasin	17.4	18.2	26.2
Medford Service Area	12.5	14.6	22.5
Other	4.9	3.6	3.7
Umpqua Subbasin	15.4	13.5	17.7
Coos Bay Service Area	6.5	7.2	11.3
Other	8.9	6.3	6.4
Other Oregon Coastal Areas Subbasin	8.8	8.1	10.8
Astoria Service Area	3.4	3.5	5.2
Other	5.4	4.6	5.6
Washington Coastal Subbasin	13.5	11.3	13.8
Aberdeen Service Area	7.0	5.6	6.6
Chehalis-Centralia Service Area	3.2	2.6	3.1
Other	3.3	3.1	4.1
Total Subregion	55.1	51.1	68.5

Table 141 - Projected Industrial Organic Waste Discharges
Subregion 10

	1980	2000	2020
		(1,000's P.E.)	
Pulp and Paper	1,126.5	902.0	980.0
Lumber and Wood Products	9.3	5.7	5.4
Food Products	34.2	31.4	43.6
Total	1,170.0	939.1	1,029.0

Treatment Costs

Curves showing estimated costs of constructing (total capital) and operating (annual operation and maintenance) municipal sewage treatment plants for various treatment levels are presented in the "Means to Satisfy Demands" section of the Regional Summary.

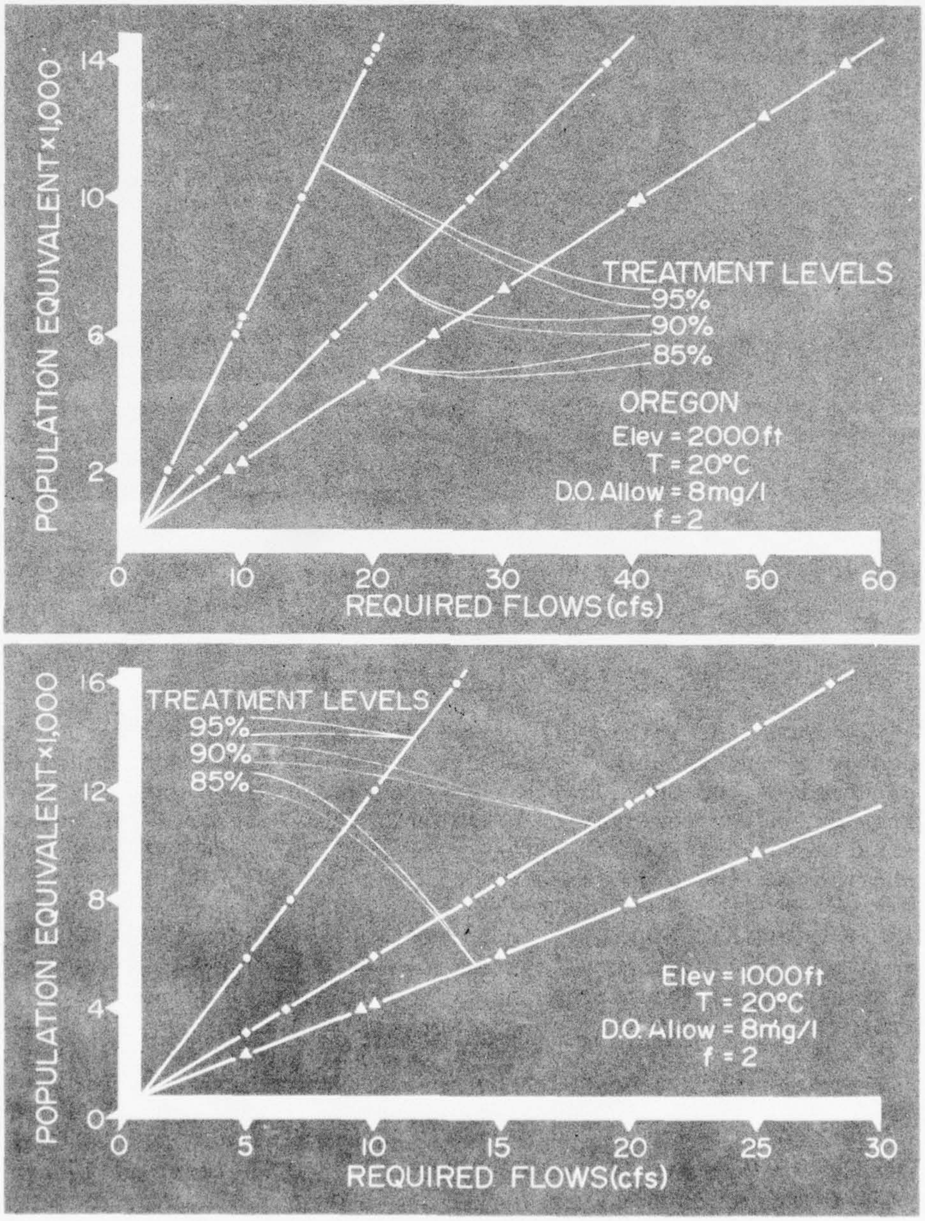


FIGURE 103. Minimum Flow Needs to Maintain Oregon and Washington Dissolved Oxygen Standards Criteria (Elevation 2000 and 1000 feet)

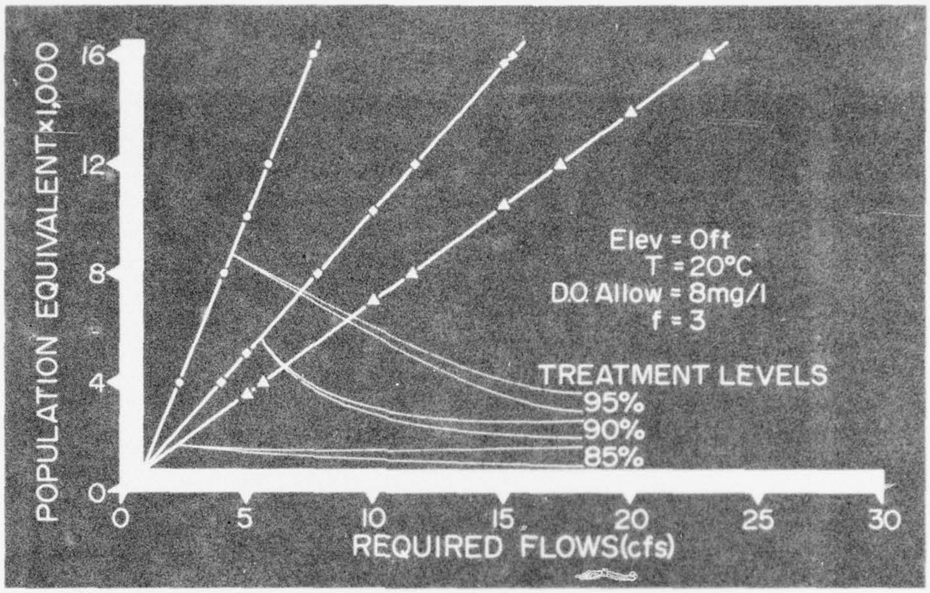


FIGURE 104. Minimum Flow Needs to Maintain Oregon and Washington Dissolved Oxygen Standards Criteria (Sea Level)

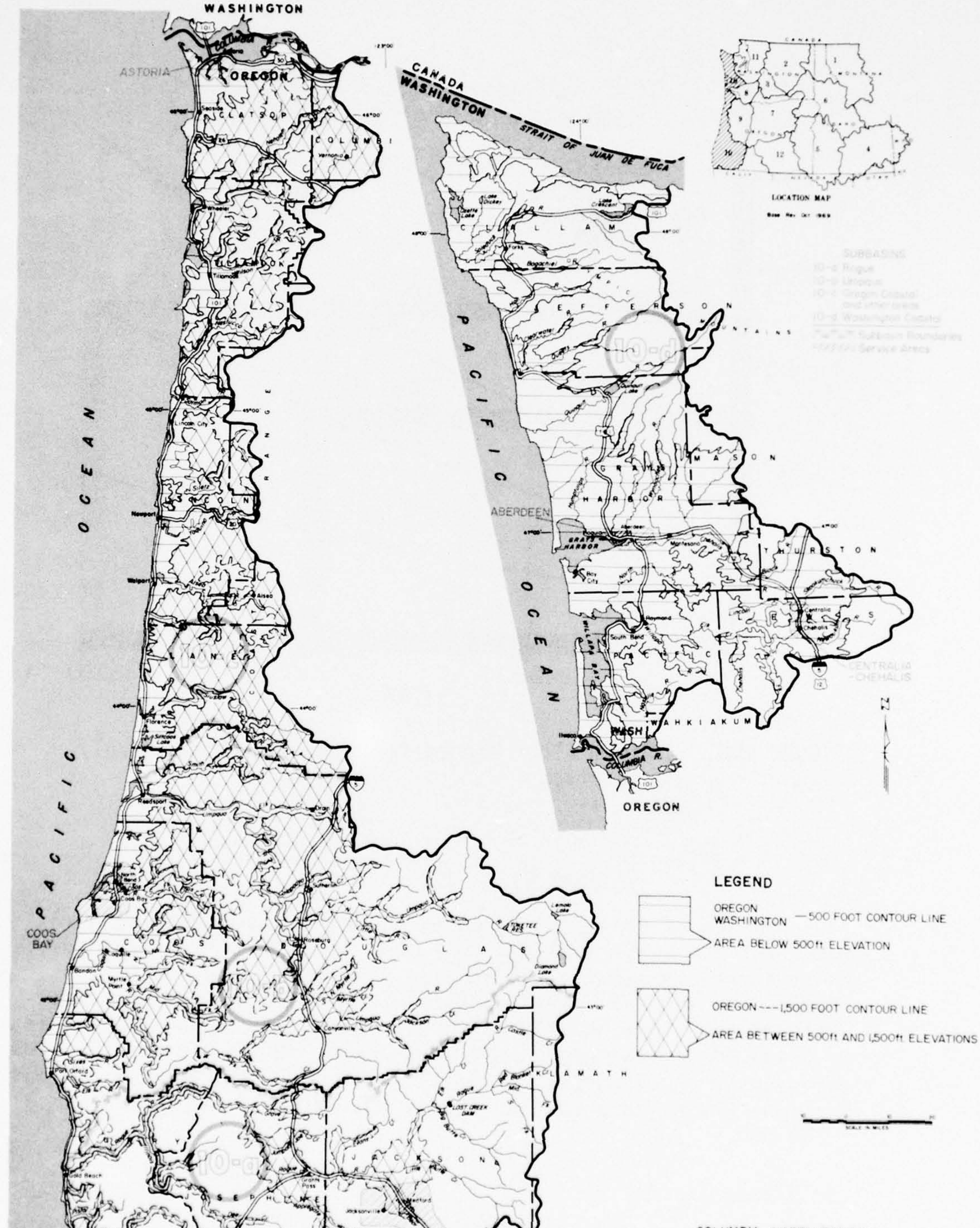
Other Pollution Control Practices

Disposal of watercraft wastes such as trash garbage, debris, sewage, oil, and gasoline, directly to the waters without treatment is presently a common practice. The control of such wastes will largely depend on legislation prohibiting the discharge and requiring these wastes to be retained in holding tanks for disposal on shore or on the high seas.

Recreation areas will be increasing in number throughout the subregion. Sewage disposal systems and refuse disposal adequate to cope with weekend loads from use by thousands will be needed in many recreation areas.

Dredging practices must be modified to minimize turbidities and reduce the toxic and oxygen-demanding materials and scheduled at times when the least amount of damage will Disposal of the dredge spoils should preferably be on land where it will have the least influence on water quality.

It is known that clearcutting extensive areas of forest lands will raise stream temperature until sufficient vegetation cover is restored to provide stream shade. Methods of harvesting stream bank timber left for shade production need further development.



COLUMBIA-NORTH PACIFIC
COMPREHENSIVE FRAMEWORK STUDY

AREAS TO WHICH FIGURES 103 AND 104 APPLY

COASTAL SUBREGION 10

1970

FIGURE 105

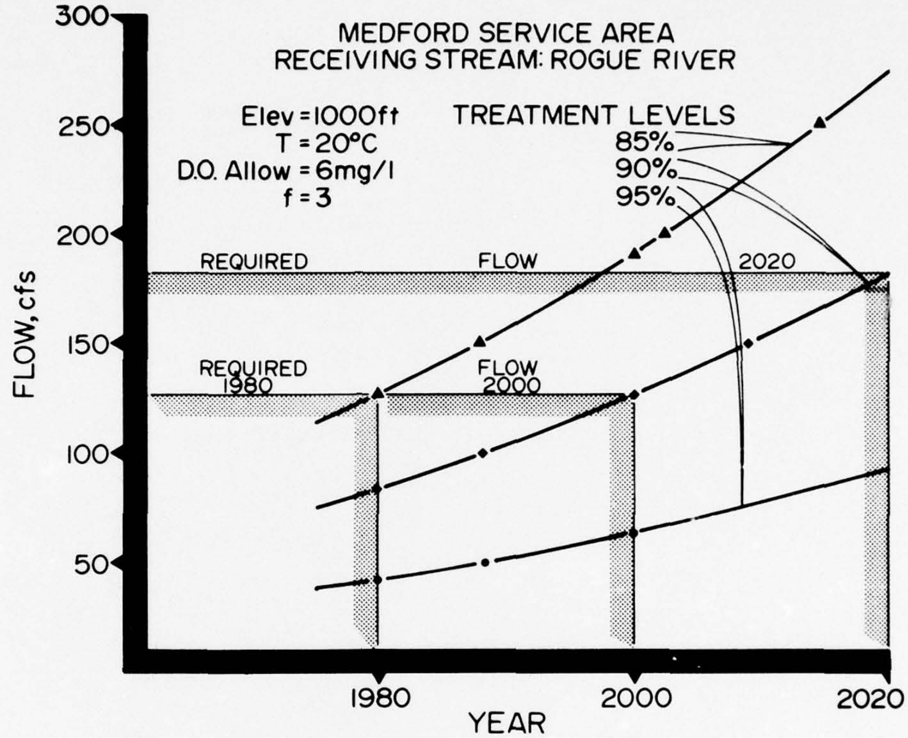


FIGURE 106. Minimum Flows Needed for Water Quality Control, Rogue River

Minimum Flow Requirements

A set of generalized curves showing minimum flow requirements for raw waste loadings subjected to various treatment levels is presented in figures 103 and 104 for several D.O. objectives, elevations, and self-purification factors (a combined characteristic of the waste and stream). Figure 105 shows generalized areas to which particular graphs are applicable. These figures give only approximate requirements for small to middle-sized communities with a normal mix of domestic and industrial wastes.

Medford Service Area

The population of the Medford Service Area is expected to increase from 72,600 in 1965 to 180,400 in 2020. The major industrial waste will continue to be from the lumber and wood products industries and the food-processing industries. Food processing is

a seasonal operation; however, most of the waste will continue to be treated in septic tanks and sub-surface disposal with only a small amount reaching the waterways.

Figure 106 shows the minimum streamflow requirements for 1980, 2000, and 2020 for assimilation of organic waste. The minimum required flow of 183 cfs in 2020 is well below the one-in-ten-year mean monthly low flow of 720 cfs near Eagle Point. The projection includes the maximum month waste production from the food-processing industries.

Coos Bay Service Area

The population of the Coos Bay Service Area is projected to increase from 31,300 in 1965 to 90,300 in 2020. The major industrial waste material will continue to be from the pulp and paper industries and from seafood processing. The existing pulp mills are expected to expand, with the possibility of an additional new mill being constructed. The mills are expected to employ chemical recovery followed by waste treatment to reduce the organic load to an acceptable level. The seafood-processing plants are expected to provide treatment of waste before discharge.

Astoria Service Area

The population of the Astoria Service Area is expected to increase from 17,700 in 1965 to 41,600 in 2020. Seafood processing is the primary industry, and most of the plants provide solids waste removal. The Oregon Water Quality Standards require that wastes be accorded secondary treatment or the equivalent before discharge into the Columbia River. No water quality problems are anticipated after treatment is provided.

Aberdeen Service Area

The population in the Aberdeen Service Area is expected to increase from 35,500 in 1965 to 52,500 in 2020. The principal waste source will continue to be the pulp and paper industries. The Washington Water Quality Standards require secondary treatment and outfall improvement for the major portion of the waste discharged into Grays Harbor. Because of the accumulated sludge deposits and upwelling, it is expected the water quality will be below standards until the sludge has oxidized.

Chehalis-Centralia Service Area

The population of the Chehalis-Centralia Service Area is projected to increase from 17,300 in 1965 to approximately 25,000 in 2020. The organic waste load produced by food-processing plants either enters the municipal sewers or is disposed of on the land. Several sand-and-gravel and mining operations in the area are a source of sediment and inorganic material.

Other Minimum Flow Requirements

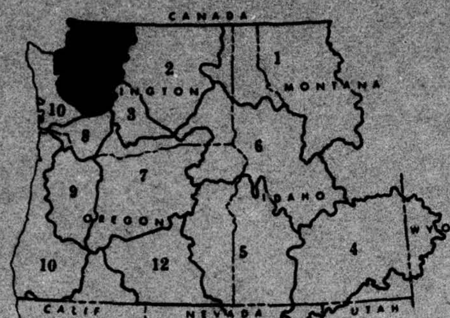
Rural wastes will be of major significance in a number of areas. The disposal of wastes to septic tanks and absorption fields will continue to represent a possible hazard to the shallow aquifers, the source of most rural water supplies. The dairy farms in the coastal valleys will also continue to produce significant amounts of raw organic wastes. These wastes for the most part are disposed of on the lands, and a small amount reaches the waters.

Should the price of gold increase, it is expected that the mines in Josephine, Jackson, and Grant Counties will be reactivated. Mining and sand-and-gravel operations create localized problems of turbidity and sedimentation.

Management Practices

The states occupy a strategic position in water quality management. They are the focal point and have the responsibility for water pollution control. The ability of the pertinent state agencies to discharge their responsibilities must be strengthened in order to enhance the effectiveness of their roles in water quality management by engineering and planning developments.

The uses of each body of water and water courses must be firmly established and the system managed to protect all the uses. The physical and biological characteristics of each body of water must be evaluated and understood to adequately predict the results of any development or changes in the system.



LOCATION MAP

SUBREGION

11

SUBREGION 11

PUGET SOUND

INTRODUCTION

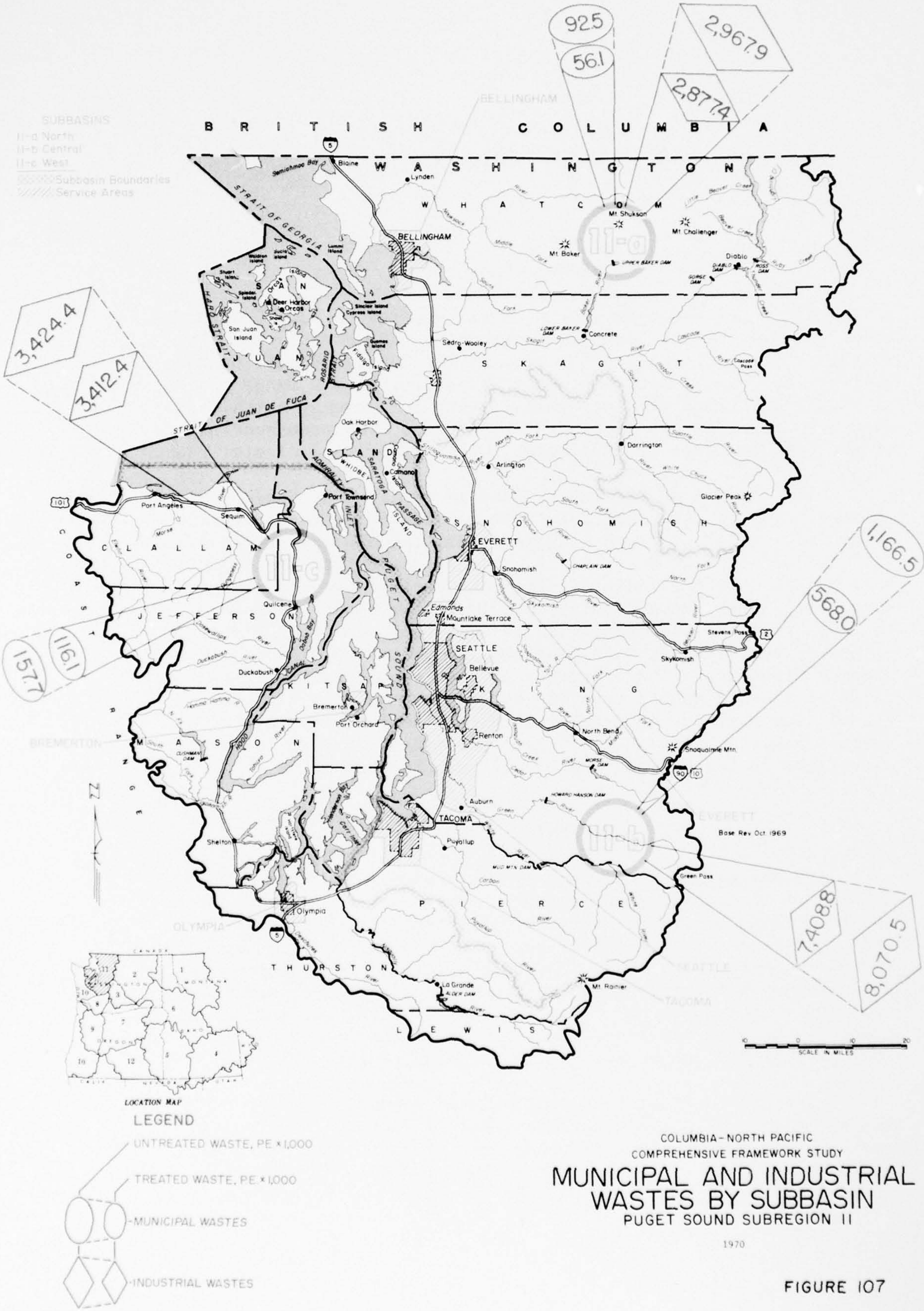
The Puget Sound Subregion covers an area of 13,355 square miles entirely in the State of Washington. The area is bounded on the north by Canada, on the east by the Cascade Range, on the west by the Olympic Mountains, and on the south by a range of low hills. The central physiographic feature is a broad, north-trending structural trough flanked by mountains. The prominent cones of the Cascade Range are Mr. Baker, Mt. Rainier, and Glacier Peak.

The climate of the Puget Sound is typified by cool, dry summers and mild, wet winters. Mean annual temperatures average about 50° F. (10° C.), and extreme annual temperatures range from -20° to 106° F. (-28.9° to 41.1° C.). Predominating air circulation brings moisture-laden air from the Pacific Ocean into the area. Resulting annual average precipitation ranges from less than 20 inches in the western sector of the Sound, in the "rain shadow of the Olympics," to over 100 inches in the Olympic and Cascade Mountains. Three-fourths of the annual precipitation falls in the six months from October through March. Light rains account for most of the precipitation at the lower elevations, whereas heavy winter snows are the predominant form at the higher elevations in the Cascade and Olympic Mountains.

PRESENT STATUS

In the past several decades the economy has changed from dependence on natural resources to a more diversified commercial and industrial base. However, forest industries, agriculture, and commercial fisheries still represent a significant economic force. Industries such as aerospace, aircraft, food processing, pulp and paper making, and petroleum refineries are becoming increasingly important. The port facilities in this subregion are among the best on the West Coast. The numerous islands in the area also provide an outstanding recreation source.

This is the most heavily populated subregion in the C-NP Region, with 1.97 million persons, which is about 32 percent of the Region's total. They are concentrated along rivers and along the eastern shores of Puget Sound. The six major service areas account for about 68 percent of the subregion's population.



COLUMBIA-NORTH PACIFIC
COMPREHENSIVE FRAMEWORK STUDY

MUNICIPAL AND INDUSTRIAL WASTES BY SUBBASIN

PUGET SOUND SUBREGION II

1970

FIGURE 107

The Puget Sound Subregion (figure 107) is divided into the North, Central, and West Subbasins. The major service areas within these subbasins are the Bellingham, Everett, Seattle, Tacoma, Olympia, and Bremerton areas.

Municipalities and industries are the largest sources of organic wastes in the Puget Sound Subregion. A graphical summary of the municipal and industrial waste production and discharge is also shown in figure 107 for each subbasin. The pulp and paper industry is the major source of oxygen-demanding wastes. Other important waste sources result from navigation and dredging operations, recreation, and land use and management practices.

The major rivers contain high quality water suitable for almost all uses. However, in the lower reaches near the Sound, urban and industrial buildup has had a measurable effect on water quality. In several streams bacterial counts are higher and dissolved oxygen levels are lower than desirable levels. In addition, some bays, harbors, and inlets have shown water quality degradation.

Stream Characteristics

The principal rivers draining the east slope of the Olympic Mountains are the Elwha and Skokomish Rivers. The Dungeness River discharges only about one-third as much water as the adjacent streams, because the basin lies in the rain shadow of the Olympic Mountains. Numerous rivers drain the west slope of the Cascade Mountains. Some of them originate in the glaciers located in the North Cascades. These glaciers tend to regulate streamflow by accumulating and storing precipitation during cold, wet years and releasing more than average amounts of water during hot, dry years. The principal rivers in the western Cascade Mountains are the Nisqually, Puyullup, Green, Cedar, Snohomish, Stillaguamish, Skagit, and Nooksack Rivers.

Average annual runoff of all streams amounts to about 53,100 cfs (38.45 million acre-feet), of which about 1,000 cfs originate in Canada. This provides an average discharge of 3.9 cfs per square mile, the highest rate of runoff of any subregion in the Columbia-North Pacific Region.

Surface-Water Hydrology

Streams heading in the Olympics exhibit two peak flow periods; one during high winter precipitation, and the other during the spring rains and snowmelt period. Generally, the greatest

Table 142 - Modified Mean Discharge, Subregion 11 (12)

	Jan.	Feb.	March	April	May	June	July (CFS)	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
Elwha River near Port Angeles, Wash.	1,711	1,609	1,226	1,341	2,052	2,265	1,554	828	584	864	1,510	1,930	1,456
Dungeness River near Sequim, Wash.	342	346	265	331	602	716	505	264	175	203	313	388	371
Duckabush River near Brinnon, Wash.	456	445	332	397	587	549	362	157	118	259	486	560	392
North Fork Skokomish River near Hoodsport, Wash.	616	565	430	518	702	622	358	150	129	349	639	765	487
Nisqually River at LaGrande, Wash.	2,312	2,132	884	1,283	1,171	1,330	895	718	1,156	914	1,648	2,182	1,385
White River at Greenwater, Wash.	681	644	602	867	1,393	1,557	1,122	682	466	467	690	880	837
Puyallup River at Puyallup, Wash.	3,736	3,547	3,297	3,610	4,274	4,557	3,175	2,035	1,629	2,076	3,253	4,336	3,292
Green River near Auburn, Wash.	1,922	1,764	1,758	1,992	1,871	1,242	517	254	237	612	1,408	2,090	1,306
So. Fork Skykomish River near Index, Wash.	2,189	1,976	1,934	2,900	4,531	4,250	2,176	791	708	1,692	2,570	2,908	2,385
Snoqualmie River near Carnation, Wash.	4,274	4,099	3,872	4,465	5,263	4,699	2,324	1,028	1,230	2,846	4,639	5,500	3,714
So. Fork Stillaguamish River near Granite Falls, Wash.	1,315	1,186	1,053	1,236	1,377	1,159	575	253	407	1,027	1,362	1,588	1,045
No. Fork Stillaguamish River near Arlington, Wash.	2,441	2,229	2,005	2,170	2,153	1,698	843	430	599	1,532	2,300	2,842	1,770
Skagit River near Hope, B.C.	423	464	454	1,154	2,780	2,806	1,316	493	304	406	562	566	977
Skagit River near Newhalem, Wash.	4,367	5,429	1,604	2,047	4,170	8,351	5,953	3,189	2,470	3,780	5,837	5,022	4,351
Sauk River near Sauk, Wash.	3,634	3,490	3,108	4,190	6,968	7,938	5,606	2,716	2,014	2,939	3,899	4,353	4,241
Skagit River near Concrete, Wash.	13,823	15,056	7,965	10,879	19,288	25,531	18,278	9,425	7,687	11,662	16,206	14,888	14,224
Nooksack River at Deming, Wash.	3,352	2,996	2,886	3,350	4,569	4,619	3,189	1,804	1,692	2,738	3,430	3,975	3,217

monthly flows occur in May and June. By contrast, winter flows are more variable and are often characterized by sharp rises due to storms. Where the effect of the rain shadow is not pronounced, the winter peak becomes dominant and the two seasonal peaks tend to merge into one long period of high flows. In general, minimum monthly flows of streams in the southern portion of the Olympic Peninsula occur during the months of August and September, whereas in the northern areas minimum flows extend into October. In the eastern portion of the subregion, the numerous glaciers have the effect of supplementing streamflows and practically eliminating extreme low flows during summer months. At high altitudes the minimum runoff occurs in February and March, but at lower elevations the minimum flow in streams normally occurs in September. Streamflow from October to March is characterized by a series of sharp rises superimposed on an increasing base flow which is highest in December. As temperatures begin to rise in April, snowmelt causes a rise in streamflow which usually reaches a peak by mid-June. Table 142 presents monthly discharge data for selected stations.

From the standpoint of waste discharge control, the low-flow months from August to October are the most important. One-in-ten-year low flow is the selected recurrency frequency for predicting critical low flows. These data are summarized for selected stations in table 143.

Table 143 - One-in-Ten-Year Monthly Low Flows, Subregion 11 (12)

Stream and Location	Low Flow (cfs)1/
Elwha River near Port Angeles, Washington	330
Dungeness River near Dequim, Washington	98
Duckabush River near Brinnon, Washington	55
North Fork Skokomish River near Hoodsport, Washington	52
Nisqually River at LaGrande, Washington	0
White River at Greenwater, Washington	240
Puyallup River at Puyallup, Washington	980
Green River near Auburn, Washington	130
South Fork Skykomish River near Index, Washington	310
Snoqualmie River near Carnation, Washington	500
South Fork Stillaguamish River near Granite Falls, Wash.	86
North Fork Stillaguamish River near Arlington, Wash.	190
Skagit River near Hope, British Columbia	120
Skagit River near Newhalem, Washington	1,000
Sauk River near Sauk, Washington	900
Skagit River near Concrete, Washington	5,100
Nooksack River at Deming, Washington	950

1/ Period of one month

Impoundments and Stream Regulation

At present, there are over 20 major impoundments in the Puget Sound Subregion, providing a total storage capacity of about 3.14 million acre-feet. The storage in these impoundments has been allocated for the purposes of municipal water supply, power, flood control, recreation, and irrigation.

Few effects on water quality have been documented for the major reservoirs in the subregion. Ross Dam modifies the temperature regime of the downstream reaches of the Skagit River with little effect. Probably the most significant adverse effect has been on the White River, a tributary of the Puyallup. Mud Mountain Dam is operated as a single-purpose flood control structure, storing the winter and spring floods which carry substantial suspended material of glacial origin. To prevent a buildup of this material on the reservoir floor, the reservoir is flushed out each fall. This introduces a large slug of sediment to the White River during its low-flow period, seriously degrading water quality. This operation procedure is undergoing review to find a means which will achieve the same results without impact to water quality. Lake Whatcom receives inflows diverted from the Middle Fork of the Nooksack River which contain large sediment loads of glacial origin. There has been no noticeable effect upon the lake from the suspended material, but the study is continuing to discern any adverse trend.

Ground-Water Characteristics

Relatively young alluvial and glacial deposits form a deep fill throughout most of the lowland, and moderate to large yields are available at many places from the sand and gravel of these deposits. The largest yields generally are from glacial outwash gravels in the south half of the lowland; yields of more than 6,000 gpm (gallons per minute) have been recorded. At places, however, the deposits include thick layers of clay, silt, fine sand, or till which yield little or no water. Young volcanic rocks crop out in relatively small areas in the mountains. Their chief hydrologic significance is in serving as ground-water reservoirs, supplying summer flow to streams draining them.

Older volcanic and consolidated sedimentary rocks crop out at a few places in the lowlands and in the highlands flanking the basin. Generally, they yield only small mounts of water sufficient for small public and industrial supplies.

Other consolidated and crystalline rocks form the core of the Olympic Mountains, the Cascade Range north of the Snoqualmie

River, and most of the San Juan Islands. These rocks generally have a low porosity and permeability, and yield only small supplies to wells. However, a fairly thick zone of weathered material with talus, landslide, and other debris forms a shallow groundwater reservoir that is important in maintaining the summer flow of streams.

The water throughout the Puget Sound Subregion usually has dissolved solids of less than 150 mg/l. Silica concentrations are generally found in the range of 20 to 60 mg/l, and the water is a soft to moderately hard calcium-magnesium bicarbonate type. Excessive iron probably causes more problems than any other constituent or characteristic. Temperature generally ranges 48° to 55° F. (9° to 13° C.).

Pollution Sources

The municipal and industrial waste production and treatment, in population equivalents, in the Puget Sound Subregion are summarized by subbasin in table 144.

At present, municipalities and industries in the subregion produce wastes equivalent to those from a population of approximately 15.9 million persons. Of this total, 82.7 percent is generated by the pulp and paper industry, 8.9 percent by municipalities, 8.0 percent by the food-processing industry, and .4 percent by the lumber and wood products and other industries.

Waste treatment and other means of waste reduction decrease the normal waste discharge to the subregion's waters by about 13 percent, so that 14.44 million population equivalents actually reach waterways. Of this total, 88.9 percent is discharged by the pulp and paper industry, 5.1 percent by municipalities, 5.6 percent by the food-processing industry, and 0.4 percent by other industries. About 13.42 million PE are released to marine waters, and 1.02 million PE are discharged to fresh waters.

Other significant sources of pollution include wastes from the rural-domestic population, irrigation, agricultural animals, land use and management, navigation and dredging, recreation, and natural sources. Land use is probably the most important of these, since it contributes heavily to sediment problems in the subregion.

Municipalities

North Subbasin Approximately 63,940 persons or 47 percent of the North Subbasin population, are served by municipal waste

treatment systems. In general, municipal waste treatment facilities are in need of improvement or upgrading. An average reduction in biochemical oxygen demand of only 40 percent is accomplished, so that 56,120 PE are released to waterways. Of the 18 municipal systems, only four provide secondary treatment.

The Bellingham Service Area accounts for nearly half of the municipal waste discharge. The City of Bellingham operates a primary treatment plant which discharges an organic loading of about 27,300 PE to Whatcom Creek. South Bellingham has a sewer collection system which discharges raw sewage to Bellingham Bay.

The cities of Sedro Woolley, Mt. Vernon, and Burlington discharge normal waste loadings of 4,200, 9,000, and 800 PE respectively, to the lower Skagit River. In addition, from July to October the Mt. Vernon system treats food-processing wastes, which increase the effluent loading to about 58,000 PE. Each of the communities is in need of additional and/or improved treatment.

The communities of Blaine, Ferndale, Lynden, Anacortes, and Friday Harbor are also major municipal waste sources. Only Lynden with a secondary treatment plant has an adequate level of treatment. The raw sewage collected by the town of Friday Harbor is emptied into the harbor through three outfalls. The remaining communities have primary treatment facilities or the equivalent.

<u>Central Subbasin</u> In the Central Subbasin, 870,374 persons, or 54 percent of the subbasin population, are served by municipal waste treatment facilities. An average reduction in the oxygen-demanding waste load of about 52 percent is achieved, so that 568,050 PE are released to waters of the subbasin. The prevailing level of waste treatment is primary. However, a number of systems operate adequate lagoons or secondary treatment plants.

The Seattle Metropolitan Area is the largest municipal waste source in the Columbia-North Pacific Region. Approximately 260,000 PE are discharged from the service area. The area is primarily served by the waste collection and treatment facilities of the Municipality of Metropolitan Seattle (METRO). METRO operates treatment plants at West Point, Alki Point, Carkeek Park, Richmond Beach, Renton, Diagonal Avenue, and Tukwila. Wastes collected for treatment in the Diagonal Avenue and Tukwila plants are scheduled to be intercepted for treatment in the large Renton secondary treatment plant. However, at present these facilities discharge a waste loading of about 34,000 PE to the Duwamish River. The West Point primary treatment plant is the largest in the Pacific Northwest, discharging abut 113,000 PE to Puget Sound. The three other METRO primary treatment plants discharge about 41,000 PE to Puget

Table 144 - Summary of Municipal and Industrial Waste Treatment, Subregion 11 (11)

	Municipal					Industrial				
	Primary	Secondary	Lagoons	Other	Total	Pulp and Paper	Wood & Lumber Products	Food Products	Other	Total
North Subbasin										
Number of facilities	11	4	0	3	18	2	1	19	5	27
Population served	52,940	6,050		4,950	63,940					
PE produced	80,090	7,000		5,400	92,490	2,465,000	6,000	491,870	5,075	2,967,945
PE discharged	49,270	1,450		5,400	56,120	2,465,000	6,000	404,670	1,750	2,877,420
% removal efficiency	39	80		0	40	0	0	18	66	4
Central Subbasin										
Number of facilities	38	6	8	5	57	8	4	25	4	41
Population served	676,523	110,700	81,400	1,751	870,374					
PE produced	902,150	122,100	140,100	2,150	1,166,500	7,306,200	20,000	720,300	24,000	8,070,500
PE discharged	531,620	8,990	25,290	2,150	568,050	7,029,000	19,500	336,500	23,750	7,408,750
% removal efficiency	42	93	82	0	52	4	3	54	2	9
West Subbasin										
Number of facilities	18	4	2	5	29	5	2	6		13
Population served	79,840	1,800	1,000	24,800	107,440					
PE produced	119,885	2,550	1,250	34,000	157,685	3,355,000	3,800	65,600		3,424,400
PE discharged	81,660	580	100	33,800	116,140	3,348,000	3,800	60,600		3,412,400
% removal efficiency	32	78	92	1	27	1	0	8		1
Total										
Number of facilities	67	14	10	13	104	15	7	50	9	81
Population served	809,303	118,550	82,400	31,501	1,041,754					
PE produced	1,102,125	131,650	141,350	41,550	1,416,675	13,126,200	29,800	1,277,770	29,075	14,462,845
PE discharged	662,550	11,020	25,390	41,350	740,310	12,842,000	29,300	801,770	25,500	13,698,570
% removal efficiency	40	92	85	1	48	3	2	38	13	6

Sound. Major waste loadings in the Seattle Metropolitan Area are also contributed by the Southwest Suburban Sanitary District and the cities of Edmonds and Lynnwood. The primary treatment plants in these areas release about 22,500, 24,000, and 6,300 PE, respectively, to Puget Sound. Other major waste sources are the cities of Kent and Auburn, which release about 10,770 and 5,000 PE, respectively, to the Green River. A few small sanitary districts contribute minor waste loadings to Puget Sound, but most are scheduled to be intercepted by the METRO system. In addition, about 50 tons per day of digested sludge are discharged to the Sound from several Seattle area treatment facilities.

The Tacoma Service Area accounts for a municipal waste loading of about 193,000 PE to subbasin waters. The city's three primary treatment plants discharge about 130,000 PE to the Puyallup River and 63,000 PE to marine waters. The dry weather flow to the largest primary facility often exceeds its hydraulic capacity, with the result that raw sewage is bypassed to the Puyallup River and into Commencement Bay. Near the Tacoma Service Area, the Fort Lewis Military Reservation and the town of Steilacoom are important waste sources. The Fort Lewis sewage system, after primary treatment, discharges 45,000 PE into Cormorant Passage. The Steilacoom primary treatment plant releases about 4,000 PE to the Chambers Creek tidal basin.

The City of Everett has a waste stabilization pond for treatment of domestic wastes. The facility discharges about 2,000 PE to the Snohomish River. The Washington Water Quality Standards require expansion of the lagoon and disinfection of the effluent.

Other significant waste sources in the Central Subbasin are the scattered communities in the Puyallup and Snohomish River drainages and municipalities in the Oak Harbor area.

In the Puyallup drainage, the town of Puyallup, which discharges about 7,500 PE to the Puyallup River, is the principal waste source. Several other smaller communities discharge a combined waste loading of about 6,600 PE to the Puyallup River and tributaries.

In the Snohomish River area, the City of Snohomish is the largest waste source, discharging a normal waste load of 5,000 PE to the Snohomish River. However, from July to October, food-processing wastes treated in the municipal facility increase the organic waste loading to about 20,000 PE. Other municipal waste sources in the drainage area contribute only about 3,000 PE to waterways.

West Subbasin Approximately 107,440 persons, or 48 percent of the West Subbasin population, are served by municipal waste treatment facilities. An average removal of 27 percent of the organic waste loading is accomplished, resulting in the discharge of 116,140 PE. Most communities provide waste treatment at least equivalent to conventional primary treatment.

The Bremerton Service Area is the largest waste source in the West Subbasin, releasing about 32,000 PE to the waters of Sinclair Inlet. The City of Bremerton has two primary treatment plants that discharge waste loadings of about 16,000 and 13,800 PE. The Naval Shipyards located at Bremerton discharge their sanitary wastes to city sewage treatment plant #2. The City of Port Orchards also provides primary waste treatment and contributes about 2,000 PE to Sinclair Inlet.

The Olympia Service Area accounts for a municipal waste loading of about 95,000 PE to Budd Inlet. The city's primary treatment facility serves 22,000 persons and several industries connected to the sewage system, the largest being the Olympia Brewing Company, which discharges about 60,000 PE.

The towns of Port Angeles, Port Townsend, Shelton, and Poulsbo are also major waste sources in the West Subbasin. These communities discharge 15,000, 6,000, 3,400, and 1,000 PE, respectively, to the waters of Puget Sound from primary treatment plants. Winslow and Sequim are minor waste sources, contributing 630 and 250 PE, respectively, to Puget Sound.

The community of Eatonville is the only municipal waste source in the subbasin discharging to a freshwater stream. The town operates adequate waste stabilization ponds so that only 100 PE are released to the Mashel River.

Industries

North Subbasin The raw industrial waste load generated in the North Subbasin approximates over 2.96 million population equivalents, of which only about four percent is presently removed by waste treatment before discharge. Over 90 percent of the waste load is released to marine waters, and the remainder is discharged to fresh waters. The lower Skagit River, Bellingham Bay, and Guemes Channel receive the largest quantities of wastes. The principal waste sources are the pulp and paper, and food products industries.

The major waste sources are the pulp and paper mills at Bellingham and a paper company at Anacortes. These mills account for nearly 85 percent of the total organic waste discharge. The

Bellingham calcium-base sulfite pulp, board, and paper mill discharges 1,687,000 PE to Bellingham Bay. The paper mill discharges 778,000 PE to Guemes Channel.

A number of seafood and food-processing and packing plants operating in the subbasin discharge wastes with only minimal treatment. A total organic loading equivalent to that from a population of 404,670 persons is released during the processing season. The major waste production is in the Mt. Vernon, Lynden, Bellingham, Anacortes, Burlington, and Friday Harbor areas. These areas account for waste loadings of about 66,000, 25,700, 58,600, 40,000, 40,200 and 2,800 PE, respectively. The food products industries at Mr. Vernon and Burlington discharge primarily to the Skagit River, and in Lynden disposal is made to the Nooksack River. In the other areas, wastes are usually disposed of to marine waters. In general, the Washington Water Quality Standards require that food-processing industries in the subbasin provide facilities to discharge all wastes to municipal sewer systems. However, if this is not possible, secondary treatment facilities are to be constructed.

The lumber and wood products industry represents a minor waste source. Only about 6,000 PE are attributed to this industry. A veneer company at Anacortes, which discharges 6,000 PE to Fidalgo Bay, is the largest waste source. The Washington Water Quality Standards require that the mill connect to the Anacortes municipal sewer system.

Other minor sources of wastes are the petroleum-processing and primary metals industries. These sources generally do not discharge high oxygen-demanding effluents, but the effluents may contain objectionable oil concentrations or toxic constituents. The refineries effectively control wastes by providing secondary treatment. Wastes which are high in temperature and which contain large amounts of fluoride are discharged by an aluminum company at Ferndale through an outfall to the Straits of Georgia.

Central Subbasin Industrial wastes in the Central Subbasin constitute about 51 percent of the total oxygen-demanding strength of all wastes discharged to waters of the Puget Sound Subregion. The raw industrial waste load generated is approximately 8.0 population equivalents, of which nine percent is removed by waste treatment. Nearly 98 percent of the wastes are released to marine waters, and the remainder are discharged to fresh waters. Elliott Bay, Commencement Bay, the Duwamish River, the lower Snohomish River, and Everett Harbor receive the largest waste loadings.

The major waste sources are seven pulp and paper mills. As a group, these mills account for an organic loading of 6,992,500

PE, or over 90 percent of the total organic waste production in the subbasin. About 95 percent of the waste loading is centered in the Everett area.

The food products industry releases an estimated waste loading of 381,400 PE. The largest quantities of wastes are discharged from plants in the Seattle Metropolitan Area and at Stanwood.

The lumber and wood products industry represents a relatively minor waste source, allowing about 19,500 PE to be released to waterways.

Other sources of wastes are the petroleum processing, primary metals, chemical products, and manufacturing industries. These industries discharge an organic loading of about 39,300 PE, but many plants contribute inorganic wastes, including oils, chemicals, acids, and other toxic materials.

In the Everett Service Area, four pulp and paper mills and several food products and lumber and wood products plants discharge about 6,740,000 PE to the lower Snohomish River and Everett Harbor. A paper company is the major waste source, discharging 4,481,000 PE to Everett Harbor. The effluent from the calcium and ammonia-base sulfite plant consists of paper mill white-waters, which have passed through save-alls for fiber recovery; clarified effluent from sedimentation facilities; and low suspended solids wastes from the pulp mill. A sulfite pulp mill produces about 1,910,000 PE. Strong digester wastes and caustic extract from the bleach plant are discharged into Port Gardner through a deepwater diffuser outfall. All other mill wastes are discharged into Everett Harbor. The same company also has a sulfate pulp mill located along the Snohomish River, which generates about 240,000 PE. Process wastes from pulp-drying machines are discharged through a sewer to the Snohomish River, while all other wastes are pumped into a large holding lagoon which discharges into Streamboat Slough. A paper company sulfate pulp and paper mill releases about 60,000 PE from settling lagoons to the Snohomish River. The mill is the principal source of suspended solids discharged to the river, contributing about 22 tons per day. Two lumber mills are located on the Snohomish River which produce liquid wastes from debarking operations. These wastes receive primary treatment, with the effluent (about 12,00 PE) being discharged to the river. The food products industry and an industrial plant also represent significant waste sources in the Everett area. These industries release about 12,600 and 15,000 PE, respectively, to the Snohomish River without treatment. The Washington Water Quality Standards require that all pulp and paper mills except sulfate mills install primary treatment. The sulfite mills must also provide for a

reduction in the discharge of sulfite waste liquor solids. In general, industrial wastes are scheduled to be intercepted by the METRO system.

Numerous food products and other industries in the Seattle Metropolitan Area discharge large quantities of organic and inorganic wastes to the Duwamish River and Elliott Bay. The total estimated organic waste loading to these water bodies are 70,900 and 130,000 PE, respectively. In addition, large quantities of inorganic chemical wastes, some of which are toxic, are released to the waters. The wastes include cyanides, chromates, pickling liquors, caustics, acids, greases, and phenols. The majority of the toxic wastes are neutralized or receive complete treatment, but some untreated wastes are discharged into the water. In general, most industrial wastes are scheduled to be intercepted by the METRO system.

In the Tacoma Service Area, the pulp and paper industry is the largest waste source. A paper company, located at the mouth of the Puyallup River, discharges about 294,000 PE into Commencement Bay. Another paper company discharges about 31,000 PE to Chambers Creek after primary treatment. Several food products, and lumber and wood products plants release about 40,000 PE to the lower Puyallup River and Commencement Bay. The Washington Water Quality Standards call for secondary treatment and submarine outfall facilities for the pulp and paper mills. Other wastes are to be intercepted by the Tacoma municipal sewer system.

Other significant waste sources in the Central Subbasin are the food products industries in the Stanwood, Snohomish, Black Diamond, and Puyallup areas; and the forest products industries in the Enumclaw and Sumner areas. The largest individual source is at Stanwood. It discharges about 185,000 PE to the Stillaguamish River from June to November.

West Subbasin The raw industrial waste production in the West Subbasin is approximately 3.42 million population equivalents, of which less than one percent is presently removed by waste treatment. Nearly 100 percent of the waste load is released to marine waters. The principal waste-receiving water bodies are Port Angeles Harbor, Port Townsend Bay, and Oakland Bay.

The major waste sources are three pulp and paper mills in the Port Angeles area. A sulfite pulp mill is by far the most significant pollution source, contributing about 2,820,000 PE and 1,157 tons of solids daily to Port Angeles Harbor. Another sulfite pulp and board mill discharges 264,000 PE and 76 tons of solids per day directly to harbor surface waters. A mill located at the inner end of the harbor, releases wastes containing 145,000

PE and 47 tons of solids directly outside the harbor. Generally, these wastes are dispersed seaward by Strait currents and, therefore, are not prominent within the main Port Angeles area. However, during past years now-discontinued discharges of high suspended solids wastes into the Port Angeles Harbor substantially contributed to a large sludge bed still present at the inner end of the harbor. A plywood mill located along the inner southern shore of Port Angeles Harbor discharges into the harbor glue waste containing an organic strength of 2,000 PE.

A pulp and paper mill discharges an organic waste loading of about 96,000 PE without treatment to Port Townsend Bay.

The major waste producer in the Shelton area is a timber company, which discharges 23,000 PE to the waters of Oakland Bay. The mill is to install secondary treatment.

Other relatively minor industrial waste loadings are discharged to Budd Inlet from the Olympia area, and to Sinclair Inlet from the Bremerton area.

Rural-Domestic

Approximately 930,900 persons, or 47.2 percent of the subregion's population, are served by individual waste disposal systems. Table 145 summarizes by subbasin the population and the percent of subbasin and subregion population served by the individual systems. In general, septic tanks and some type of subsurface drainage are used for waste disposal. The actual waste load reaching waterways from rural-domestic sources is not considered to be large.

Table 145 - Summary of Population Served by Individual Waste Disposal Facilities, Subregion 11 1/

Subbasin	Thousands Population Served	Percent Subregion Population	Percent Subbasin Population
North	71.9	3.6	52.9
Central	744.8	37.8	46.1
West	114.2	5.8	51.5
Total	930.9	47.2	

1/ Derived as a residual from FWPCA Municipal and Industrial Waste Inventory, Puget Sound Subregion, 1965.

Irrigation

The total area for which water is diverted in the Puget Sound Subregion is about 91,700 acres, or 1 percent of the total land area. Diversion rates per acre average about 2.5 acre-feet per year, or a total volume of about 227.5 thousand acre-feet per year. Abundant quantities of water are generally available for use.

Irrigation is not considered to be a major pollution source in the Puget Sound area. The conditions peculiar to the area tend to minimize any detrimental effects on water quality. First, the amount of water applied per acre amounts to about 35 percent, or less, of the 35 to 50 inches of the average annual precipitation that falls in most of the lowlands. This means that the more easily dissolved constituents have already been removed. Second, irrigation water, where and when used, is usually applied by sprinkler, the method which is most efficient and least likely to cause leaching or surface washing. Third, the subregion's mild climate permits live, viable roots to abound in the soil even during winter. This tends to utilize all of the available nitrogen and to prevent its being leached out of the soil. Fourth, little, if any, phosphorus would be leached out when applied as fertilizer, because Puget Sound soils have a high iron content that tends to complex phosphorus into the insoluble compounds.

Agricultural Animals

The grazing and feeding of farm animals are also sources of wastes in the Puget Sound Subregion. Most of this waste that is produced receives land deposition, but rain and irrigation waters flush part of it into streams and ponds. Dairies, feedlots, and other animal concentrations along streams cause accelerated erosion, as well as intensifying the potential coliform bacteria and biochemical oxygen demand in the water. The amount of animal wastes which reach the waterways is unknown. However, it is estimated that a potential waste loading equivalent to that from a population of 3.4 million exists in the subregion. If only five percent of these wastes reached the stream through feedlot and pasture runoff, it would represent an organic loading of 100,000 PE. A study now being established on the dairy herd located on Washington State's honor farm near Monroe, Washington, should provide considerable specific information on the dairy waste problem.

Other Land Uses

Land use practices can substantially alter the physical environment of a river basin and affect water quality. The production and transport of sediment are the most significant quality impairments resulting from land use in the Puget Sound Subregion.

The subregion is heavily forested, with 84.6 percent of the total land area classified as woodland. Timber harvesting, along with its road construction requirements, creates the most serious accelerated soil erosion problems on Puget Sound's forested watershed. Clear-cutting--a standard practice in the Douglas fir forests of this area--can lead to greatly accelerated erosion where the ground cover is disturbed. Yarding methods, such as the skyline system, can minimize ground disturbance and not result in accelerated erosion.

Sediment yield ranges from 0.1 to 0.5 acre-foot per square mile per year; only about 3 percent of the subregion has a yield greater than 0.2 acre-foot per square mile per year. The few higher yields are generally associated with glacial erosion. Most of the sediment probably results from channel erosion on the mountainous watersheds. The most damaging type of sediment, however, apparently results during peak storm runoff as scour in mountain channels and as bank erosion in alluvial reaches of the larger streams. Some scour in mountain channels is associated with logging practices.

The cropland (6.8 percent of the total land use) exists wholly on the alluvial fans, on the gently sloping river plains and terraces, and on open foothills. In general, these areas constitute only minor pollution sources resulting from the runoff of organic and inorganic pesticides and fertilizers. Evidently some of Puget Sound's croplands have fertilizers applied to them at rates much heavier than those normally used in other parts of the State of Washington. This is illustrated by the fact that 3.1 percent of the State's farmland that is in Puget Sound received 12 percent of the total fertilizer reportedly used in Washington in 1964. Even with such large amounts of fertilizer elements being applied, however, little is leached or washed away in the surface waters.

Recreation

Water quality problems caused by recreation activities are isolated and scattered throughout the subregion. Prior to improved sewage treatment facilities effluent from septic tanks was reaching the streams in the Snoqualmie Pass recreation area, especially in

the winter. Several recreation home developments around small lakes in West Sound have been halted because of inadequate waste-handling facilities, resulting in bacterial contamination of the lakes and ground waters. Wastes from boaters periodically concentrate in bays in the San Juan Islands and West Sound; aesthetically displeasing flotsam and litter are found everywhere.

Navigation and Dredging

Commercial vessels are a major source of unquantified pollution in marine waters. While at dock, these ships discharge raw domestic wastes directly into the harbor waters. For a naval vessel at Bremerton, this may amount to a waste load equivalent to that from a town of 3,000 people. Other wastes from ships are the oil spills and bilge waters pumped while in transit, which contain oil and other petroleum products. These create the oil slicks on the Sound which ultimately gather into oil blobs on the beaches.

Dredging normally is carried out in the estuarine areas where sediment and waste products build up to block navigable waters. In areas where new port facilities are being constructed, dredging is usually a key activity.

Dredging introduces quantities of suspended material to the local water prism. In those bottom areas where debris and sludge beds have built up from industrial waste discharges (e.g. pulp mills), dredging frees large quantities of oxygen-demanding organics in the water and may release toxic products of decomposition.

In Puget Sound, dredging is an important activity. It has not created many serious water quality problems, even though it has generally been carried out with little regard to water quality considerations. The main impact has been local turbidity.

Present Water Quality

Systematic measurements of water quality characteristics began in Puget Sound tributaries in June 1959. At that time a Water Quality Basic Data Program was put into operation as a joint effort of the Washington Water Pollution Control Commission and the Geological Survey. At least one, and often two or three water quality stations were established on all major streams, usually near existing gaging stations. Prior to that time, water quality data were collected for specific stream reaches on a unique study basis.

Marine waters in the Puget Sound Subregion have had characteristics measured systematically by the University of Washington, Department of Oceanography, since 1948. Only temperature, salinity, dissolved oxygen, and phosophates have been measured, and the stations have been widespread throughout the major areas of the Sound. The bays and harbors have been generally left to special studies or have not been covered. The recent Puget Sound Enforcement Project of FWPCA has resulted in an intensive study of Bellingham Bay, Everett Harbor, and Port Angeles Bay. Elliott Bay and Commencement Bay were also the subject of some previous studies.

Fresh Waters

The streams in the Puget Sound Subregion generally contain a high quality water suitable for almost all uses. However, in the lower reaches near the Sound, urban and industrial buildup has had a measurable effect on water quality. Dissolved solids and bacterial counts are significantly higher, and dissolved oxygen levels are lower. A summary of important water quality parameters for selected stations is presented in table 146.

Dissolved oxygen concentrations are at or near the saturation level (>80% saturation) in nearly all the streams. A few lower river reaches are subjected to the discharge of large quantities of partially treated or untreated wastes, with depressed oxygen levels resulting. These areas are located primarily on the lowlands along eastern Puget Sound. The esturial reach of the Duwamish River has low dissolved oxygen levels during the late summer and early fall. Bottom oxygen concentrations have ranged between three and four mg/l, with the minimum dropping below two mg/l. Surface concentrations during this period varied between five and six mg/l. During the low flow period, tides are a predominant factor effecting changes in dissolved oxygen. Minor increases in freshwater flows are of little value in raising oxygen levels through the depressed reach. In South Tacoma, Flett Creek has exhibited dissolved oxygen levels of 4.5 mg/l during the fall. Also, bottom dissolved oxygen levels approaching 0.0 mg/l in Lake Union result from solids deposits during past heavy industrial waste loadings.

Bacteriological quality, although variable, generally reflects the density of urban or agricultrual buildup. High densities of total coliform organisms most often occur in the lowland areas along eastern Puget Sound. Outside these developed lowlands, the streams receive little waste and are of excellent bacteriological quality. Coliform densities are generally above the limit for safe water-contact recreation (1,000 organisms/100 ml) in the Nooksack River near Ferndale; the Skagit River near

Table 146 - Summary of Water Quality Data, Subregion 11 [1/]

Location	D.O. (mg/l)	T (°C)	Coliform MPN/ 100ml	pH	Color (PT-CO) Units	Hard. (mg/l)	Turb. (JTU)	TDS (mg/l)	Ortho PO_4 (mg/l)	NO_3-N (mg/l)
Whatcom Lake										
near Bellingham, Wash.										
Mean	10.7	12.3	184	6.9	---	19	---	32	0.01	0.6
Min.	8.6	3.5	0	6.6	0	18	0	28	0.00	0.1
Max.	13.0	21.4	930	7.1	10	22	15	52	0.03	1.1
No. of samples	27	27	27	24	24	25	12	25	12	25
Nooksack River										
at Deming, Wash.										
Mean	11.2	9.3	727	7.2	---	32	---	49	0.02	0.4
Min.	9.8	2.4	0	6.9	0	22	5	35	0.00	0.0
Max.	13.4	16.4	24,000	7.8	50	44	330	68	0.21	1.0
No. of samples	41	40	41	40	40	40	20	40	37	40
Nooksack River										
at Ferndale, Wash.										
Mean	11.1	9.1	2,488	7.2	---	36	---	56	0.02	0.8
Min.	5.1	2.0	36	6.8	0	22	5	32	0.00	0.1
Max.	13.6	17.5	24,000	7.7	25	53	700	77	0.05	2.5
No. of samples	60	60	60	57	57	57	46	57	46	57
Skagit River										
at Marblemount, Wash.										
Mean	11.7	8.3	40	7.3	---	22	---	32	0.01	0.3
Min.	9.7	3.8	0	6.8	0	12	0	18	0.00	0.0
Max.	13.3	15.2	230	8.0	5	30	5	44	0.08	1.1
No. of samples	37	37	37	36	36	36	15	36	33	36
Skagit River										
near Mt. Vernon, Wash.										
Mean	11.2	9.3	1,849	7.1	---	22	---	35	0.02	0.4
Min.	9.3	4.0	0	6.3	0	13	0	0	0.00	0.0
Max.	13.7	17.8	24,000	8.1	20	32	350	52	0.07	1.5
No. of samples	88	87	87	84	84	86	44	86	73	86
Samish River										
near Burlington, Wash.										
Mean	10.8	9.7	1,003	7.1	---	27	---	49	0.03	2.2
Min.	7.0	3.8	0	6.6	0	17	0	34	0.00	0.7
Max.	13.0	19.0	11,000	7.6	40	44	90	71	0.09	4.7
No. of samples	39	39	39	36	36	36	16	36	23	36
S.F. Stillaguamish River										
near Granite Falls, Wash.										
Mean	11.7	8.8	182	7.0	---	15	---	27	0.02	0.3
Min.	8.9	1.0	0	6.1	5	9	0	15	0.00	0.0
Max.	13.8	17.7	4,600	7.4	30	29	150	42	0.11	0.7
No. of samples	36	37	37	36	36	36	12	36	33	36
N.F. Stillaguamish River										
near Arlington, Wash.										
Mean	11.6	9.2	182	7.2	---	21	---	36	0.02	0.6
Min.	9.3	2.3	0	6.7	5	12	5	22	0.00	0.1
Max.	13.8	17.6	930	7.6	30	34	110	55	0.04	1.0
No. of samples	19	19	19	18	18	18	14			
Stillaguamish River										
near Silvana, Wash.										
Mean	11.1	9.9	204	7.1	---	22	---	37	0.02	0.6
Min.	4.8	1.8	0	5.9	0	11	0	17	0.00	0.0
Max.	14.3	22.8	1,500	7.6	45	39	400	58	0.10	2.0
No. of samples	87	87	87	83	83	83	44	83	72	83
Skykomish River										
near Gold Bar, Wash.										
Mean	11.6	8.8	174	7.1	---	12	---	23	0.01	0.3
Min.	9.6	2.6	0	6.5	0	7	0	13	0.00	0.0
Max.	13.9	18.3	2,400	7.5	20	18	20	36	0.06	0.6
No. of samples	37	37	37	37	36	38	15	38	33	38

Table 146 (Continued)

Location	D.O. (mg/l)	T (°C)	Coliform MPN/ 100ml	pH	Color (PT-CO) Units	Hard (mg/l)	Turb. (JTU)	TDS (mg/l)	Ortho PO_4 (mg/l)	NO_3-N (mg/l)
Sultan River at Sultan, Wash.										
Mean	11.2	9.9	88	7.0	---	15	---	27	0.01	0.4
Min.	8.5	3.5	0	3.9	0	8	0	15	0.00	0.1
Max.	13.7	21.3	930	8.1	20	31	75	56	0.07	0.8
No. of samples	35	34	35	35	35	35	16	35		
Snoqualmie River at Snoqualmie, Wash.										
Mean	11.1	9.1	1,439	6.9	---	12	---	25	0.02	0.5
Min.	9.0	3.2	0	6.2	5	6	0	14	0.00	0.0
Max.	13.2	17.5	4,600	7.4	40	18	40	33	0.12	1.8
No. of samples	36	36	35	34	30	34	14	34	31	34
Tolt River near Carnation, Wash.										
Mean	11.1	10.6	84	7.1	---	17	---	33	0.01	0.4
Min.	8.7	3.7	0	6.6	5	9	0	21	0.00	0.1
Max.	14.7	23.2	430	7.5	30	27	50	47	0.03	1.0
No. of samples	35	34	34	34	34	34	15	34	31	34
Snohomish River at Snohomish, Wash.										
Mean	11.0	10.0	2,050	6.9	---	15	---	30	0.02	0.7
Min.	8.3	4.0	23	6.4	5	8	0	14	0.00	0.0
Max.	14.0	19.0	24,000	7.4	20	22	160	40	0.12	2.6
No. of samples	62	62	62	59	58	59	43	59		
Green River near Auburn, Wash.										
Mean	11.1	10.1	1,225	7.2	---	24	---	51	0.03	0.7
Min.	8.3	3.5	0	6.2	0	14	0	30	0.00	0.0
Max.	14.1	24.2	24,000	7.9	15	39	40	71	0.13	1.9
No. of samples	88	87	86	84	83	84	45	84	73	84
Green River at Tukwila, Wash.										
Mean	9.7	10.6	17,289	7.0	---	35	---	72	0.21	2.0
Min.	6.2	4.5	230	6.6	0	16	5	34	0.05	0.4
Max.	12.7	20.0	240,000	7.6	30	133	70	116	0.89	4.5
No. of samples	51	50	50	48	47	48	36	48	35	47
Cedar River at Renton, Wash.										
Mean	10.8	10.6	420	7.2	---	24	---	44	0.03	0.5
Min.	7.6	4.1	0	6.9	0	16	0	34	0.00	0.0
Max.	12.5	22.8	4,600	7.9	10	46	25	77	0.28	1.9
No. of samples	50	51	50	46	46	46	16	46	43	46
Sammamish River at Bothell, Wash.										
Mean	9.9	12.2	1,788	7.1	---	39	---	71	0.10	1.8
Min.	7.3	5.0	91	6.6	5	31	0	57	0.00	0.3
Max.	12.5	23.6	11,000	7.4	40	55	120	100	0.44	6.3
No. of samples	57	57	56	53	53	53	22	53	50	53
Flett Creek at Tacoma, Wash.										
Mean	8.9	11.3	5,343	7.0	---	23	---	120	0.20	10.1
Min.	4.5	7.3	91	6.3	5	15	0	98	0.07	6.8
Max.	13.2	20.1	24,000	7.8	160	36	120	156	0.98	13.0
No. of samples	36	36	36	36	36	36	36	36	36	36
Leach Creek near Steilacoom, Wash.										
Mean	10.7	9.9	1,566	7.3	---	59	---	106	0.13	4.0
Min.	9.0	5.8	0	6.4	0	38	0	83	0.02	1.3
Max.	12.6	15.0	11,000	7.8	100	68	15	121	0.19	5.4
No. of samples	36	36	36	36	36	36	36	36	36	36

Table 146 (Continued)

Location	D.O. (mg/l)	T (°C)	Coliform MPN/ 100ml	pH	Color (PT-CO) Units	Hard. (mg/l)	Turb. (JTU)	TDS (mg/l)	Ortho PO_4 (mg/l)	NO_3-N (mg/l)
Chambers Creek near Steilacoom, Wash.										
Mean	10.1	11.3	933	7.2	---	47	---	84	0.20	4.2
Min.	8.3	6.6	0	6.7	0	35	0	73	0.04	2.7
Max.	13.0	17.4	11,000	7.8	70	56	20	100	0.94	5.6
No. of samples	50	51	51	49	49	49	36	49	36	49
White River near Sumner, Wash.										
Mean	11.2	10.7	1,410	7.3	---	30	---	63	0.09	0.7
Min.	8.4	3.4	0	6.6	0	15	0	37	0.02	0.0
Max.	14.8	26.0	11,000	8.7	25	47	230	88	0.28	3.3
No. of samples	51	51	51	53	53	53	45	53	47	53
Puyallup River near Orting, Wash.										
Mean	11.4	8.0	115	7.1	---	18	---	46	0.03	0.3
Min.	9.2	1.0	0	6.2	0	13	0	32	0.00	0.0
Max.	13.4	15.0	430	7.6	40	26	500	65	0.14	1.6
No. of samples	30	29	30	32	32	32	9	32	26	32
Puyallup River at Puyallup, Wash.										
Mean	10.8	9.3	5,521	7.0	---	24	---	53	0.05	0.7
Min.	9.3	2.9	0	6.3	0	16	0	36	0.01	0.1
Max.	12.4	18.3	24,000	7.5	20	40	400	74	0.13	2.0
No. of samples	43	42	43	42	42	42	16	42	28	42
Deschutes River at Tumwater, Wash.										
Mean	10.7	10.1	646	7.2	---	34	---	74	0.07	1.1
Min.	8.7	4.0	0	6.6	5	20	0	54	0.00	0.6
Max.	11.7	20.1	2,400	7.8	20	46	30	89	0.12	1.6
No. of samples	16	16	16	15	15	15	10	15	12	15
Nisqually River at McKenna, Wash.										
Mean	11.2	9.5	247	7.1	---	20	---	47	0.04	0.3
Min.	8.6	4.8	0	6.2	0	12	0	37	0.00	0.0
Max.	12.8	20.0	2,400	7.5	25	28	25	61	0.19	0.9
No. of samples	37	37	37	37	37	37	16	37	33	37
Big Quilcene River near Quilcene, Wash.										
Mean	11.4	8.9	42	7.4	---	40	---	62	0.03	0.3
Min.	9.8	3.6	0	6.8	0	30	0	43	0.00	0.0
Max.	13.5	15.6	430	7.8	15	57	5	94	0.32	1.0
No. of samples	27	28	29	29	28	29	10	29	27	29
Dosewallips River at Brinnon, Wash.										
Mean	11.6	8.8	29	7.5	---	38	---	53	0.02	0.2
Min.	10.0	3.9	0	6.9	0	24	0	38	0.00	0.0
Max.	13.6	15.5	230	7.9	10	52	80	72	0.10	0.4
No. of samples	26	28	29	29	29	25	10	29	27	29
Duckabush River near Brinnon, Wash.										
Mean	11.8	8.5	84	7.4	---	56	---	47	0.01	0.1
Min.	8.0	4.1	0	7.1	0	20	0	33	0.00	0.0
Max.	13.9	15.1	430	7.9	10	276	25	133	0.07	0.4
No. of samples	25	26	27	27	22	26	9	---	---	---
Skokomish River near Potlatch, Wash.										
Mean	11.0	8.7	56	7.3	---	27	---	45	0.03	0.2
Min.	9.6	5.1	0	6.7	0	18	0	31	0.00	0.0
Max.	15.0	13.5	230	7.8	15	33	70	52	0.06	0.7
No. of samples	24	24	25	26	26	26	10	26	24	26
Goldsborough Creek near Shelton, Wash.										
Mean	10.5	10.4	878	7.4	---	71	---	99	0.05	0.6
Min.	8.3	4.5	36	6.8	0	20	0	40	0.00	0.0
Max.	12.5	17.0	4,300	8.2	20	136	20	178	0.13	1.9
No. of samples	23	23	23	24	12	24	12	24	12	24

1/ FWPCA STORET, 1968.

Mt. Vernon; the Sammamish River, Issaquah Creek, and Duwamish River, all near Seattle; Boise Creek near Buckley; the Puyallup River and Flett and Leach Creeks near Tacoma. Most high bacterial counts result from municipal waste loadings, either untreated or inadequately treated. In some rural areas, occasional high coliform densities occur from runoff from dairy farms or animal feedlots.

Stream temperatures of Olympic rivers are generally cooler than those of rivers on the east side of the Sound. The streams on the Olympic Peninsula, the upper Puyallup, and the upper Skagit have maximum recorded water temperatures below 61°F. (16° C.) and means around 48° F. (9° C.). Maximum temperatures over 68° F. (20° C.) have been recorded on the Deschutes, Nisqually, lower Green and Cedar, Sammamish, Sultan, Tolt, and the creeks around Lake Steilacoom. Their average water temperatures are above 50° F. (10° C.)

Sediment transport by streams in the Puget Sound Subregion has not been thoroughly measured. The highest concentrations in some streams observed in recent years, mostly since 1962, were 63,200 mg/l on the White River near Greenwater; 1,820 mg/l on the Green River; 1,620 mg/l on the Puyallup River; 1,590 mg/l on the Duwamish River; 1,220 mg/l on the Cedar River; and 1,080 mg/l on the Nooksack River. With the exception of a few streams originating in glaciers, most streams seldom exceed a sediment concentration of 300 mg/l.

Most of the streams in the Puget Sound Subregion originate in the high elevations of the Cascade or Olympic Mountains and flow over relatively insoluble materials. Rainfall is profuse, and runoff is generally rapid. The above conditions result in waters with low dissolved solids content, which averages less than 75 mg/l except in the lower reaches. The major dissolved ions in the water are calcium bicarbonate and silica. With the exception of the lower reaches of the Duwamish River and the streams below Lake Sammamish, the surface waters are soft. Hardness of water averages 40 mg/l or less, and the maximum hardness seldom exceeds 60 mg/l. There is some downstream increase in mineralization of surface waters. The increase is significant only in the Duwamish River and in streams in the Seattle-Tacoma area. Data from the Duwamish River indicate considerable variation in the chemical quality. The major causes of this variation are the influence of salt water from Puget Sound and the discharge of sewage and industrial wastes.

Measurable iron concentrations occur in all surface waters of the subregion. The PHS Drinking Water Standards recommend that soluble iron concentrations do not exceed 0.30 mg/l for prevention of objectionable tastes and laundry staining. Most concentrations

reported in Puget Sound are total iron instead of the more significant soluble iron form; therefore, it is not possible to determine the extent of the problem. However, it is known that the City of Anacortes must remove iron from the Skagit River before it can be used as a water supply.

The fresh waters of Puget Sound generally have low levels of nutrients (phosphates and nitrates) which stimulate nuisance growths of aquatic organisms such as algal blooms. Nitrate concentrations are not high in most streams. However, such concentrations in the Samish River are significantly higher than in any other stream in the Sound. A mean concentration of about 0.51 mg/l and a maximum level of 1.06 mg/l are carried by the river. Boise Creek near Buckley and Chambers, Clover, Flett, and Leach Creeks near Steilacoom are the only other streams carrying average nitrate concentrations greater than 0.30 mg/l. The phosphate content is normally quite low. Only a few streams and waterways in the Tacoma and Seattle areas receiving partially treated or untreated domestic and industrial wastes exhibit phosphate concentrations above the level for stimulation of algal growth.

A number of freshwater lakes in the Puget Sound Subregion have been adversely affected by waste discharges and by flow and land management practices, tending to hasten advanced conditions of eutrophy. Water quality monitoring for coliform bacteria is currently being conducted on several lakes heavily utilized for recreation purposes and for public supply. A number of special studies have been or are being conducted on selected lakes such as Lake Washington, Lake Sammamish, Green Lake, and Lake Whatcom.

With the postwar boom in Seattle, greater developments around Lake Washington led to greater volumes of treated sewage being discharged into the lake. By the 1950's the lake was in the early stages of nutrient enrichment, with undesirable algal growth and excessive weed growths reducing the water quality for domestic supply and outdoor recreation. In 1962, the Municipality of Metropolitan Seattle began water quality studies on Lake Washington and nearby Lake Sammamish. Shortly thereafter, a program was initiated to intercept all waste discharges into Lake Washington and dispose of them in the Sound. As a result, eutrophication has been slowed and water quality of the lake has continued to improve.

Lake Sammamish, which discharges directly to Lake Washington, is in the early stages of eutrophication. Its condition corresponds to that of Lake Washington in the 1950's prior to extensive sewerage interception. Studies of Lake Whatcom, near Bellingham, indicate high bacterial concentration along the north end due to septic tank drainage. Residential developments and

intensive land use around American Lake, south of Tacoma, presently contribute excessive phosphorus and other nutrients to this lake.

Green Lake--heavily used for recreation and lying completely within a developed residential area of north Seattle--had a long history of algal blooms resulting from extensive drainage of streets and lawns and natural springs. Increased algal blooms, swimming restrictions due to high coliform counts and "swimmer's itch," turbidity and loss of clarity from dead algal cells, semi-domesticated waterfowl, and storm overflows led to a program of investigation and rehabilitation by the Seattle Park Department. Seattle presently flushes the lake with water from its municipal supply system, resulting in elimination of most of the water quality problems.

Marine Waters

The Puget Sound is composed of many interconnected inlets, bays, and channels with seawater entering at the western end and fresh water entering at many points along the system. This large complex may be divided into nine major oceanographic regions: Strait of Juan de Fuca, Admiralty Inlet, Puget Sound Basin, Southern Puget Sound, Hood Canal, Possession Sound, Bellingham Bay, San Juan Archipelago, and Georgia Strait.

Marine water characteristics are dependent upon oceanographic and meteorologic conditions. Throughout the Sound a surface layer of less saline water overlies more dense seawater. Near the mouths of major streams, this layer is quite pronounced and stable. The boundary becomes more diffuse as the freshwater layer moves seaward as a result of vertical mixing, but the surface layer is never completely destroyed. The waters of each oceanographic area tend to be fresher as one proceeds landward, and the temperature range from winter to summer becomes greater.

Selected measured water characteristics are shown in table 147. These partially illustrate, in a general way, the variance in water characteristics of the Sound. Since they represent such a small group of measurements, however, they do not indicate the actual maximum or minimum levels, nor the extent of spatial variance. In addition, these few parameters give only an incomplete definition of the quality.

A considerable difference in the water characteristics frequently exists between the Strait of Juan de Fuca and the southern tip of Puget Sound, due to the influence of river water in certain areas and other factors. Salinities vary, on the average, from a winter minimum of 26.9°/oo to a summer maximum of 35.1°/oo. The salinity difference between the surface and bottom

Table 147 - Water Quality of Marine Waters, Subregion 11 1/

Parameters		Strait of Juan de Fuca		Admiralty Inlet		Puget Sound Basin		Southern Puget Sound*		Hood Canal*		San Juan Island*		Bellingham Bay*		Georgia Strait*	
		Fall Winter	Spring Summer	Fall Winter	Spring Summer	Fall Winter	Spring Summer	Fall Winter	Spring Summer	Fall Winter	Spring Summer	Fall Winter	Spring Summer	Fall Winter	Spring Summer	Fall Winter	Spring Summer
Temperature	°C																
Surface																	
Mean		7.6	11.3	8.0	10.5	3.5	12.0			6.0	20.0						
Maximum		11.5	11.8	9.2	12.7	12.7	15.2		16.0				12.0		12.2		15.0
Minimum		6.3	7.8	6.4	9.6	7.3	8.1	7.0				6.8		6.0		6.5	
Depth																	
Mean		8.1	6.5	8.1	9.6	8.6	8.8										
Maximum		9.0	7.0	8.9	11.1	10.9	11.2		14.0		12.0	9.4		10.5		9.0	
Minimum		6.6	6.3	6.4	7.0	6.5	7.6			8.0	10.0	7.2			7.9	6.5	
Salinity	o/oo																
Surface																	
Mean		30.85	31.0	30.5	30.0	24.3	28.0		29.5								
Maximum		31.4	31.8	32.1	30.9	30.7	30.2			28.0		31.1			30.5	30.2	
Minimum		29.8	30.6	28.5	29.0	26.9	22.8	28.0		24.0			27.6		12.0		24.0
Depth																	
Mean		33.55	34.0	30.8	31.0	30.3	30.0		29.5								
Maximum		33.8	34.1	32.4	31.8	31.0	31.1				30.8		32.5	30.5		31.0	
Minimum		32.2	33.8	28.8	29.6	29.6	29.0	28.0		29.0	30.0				29.5		30.4
Dissolved Oxygen	mg/l																
Surface																	
Mean		8.2	7.1	8.0	6.8	9.6	9.6										
Maximum		9.0	9.5	8.6	9.1	12.2	20.1		9.6		20.0		10.0		13.0		10.0
Minimum		5.1	6.6	3.8	3.8	6.4	7.0	5.6			5.0	5.6			7.0	7.0	
Depth																	
Mean		3.6	2.9	6.8	6.4	7.2	6.7										
Maximum		8.0	3.5	8.3	8.3	9.9	8.4					6.0		11.0		5.0	
Minimum		3.2	2.4	2.8	2.4	5.4	4.3					4.8			5.0		7.1
Phosphate	mg/l																
Surface																	
Mean		0.06	0.06	0.05	0.04	0.07	0.03										
Maximum		0.07	0.07	0.06	0.06	0.08	0.06	0.08	0.08	0.08							
Minimum		0.03	0.05	0.02	0.02	0.02	0.02	0.05	0.05		0.0						
Depth																	
Mean		0.07	0.08	0.06	0.06	0.07	0.06								0.06		
Maximum		0.12	0.09	0.10	0.10	0.08	0.08										
Minimum		0.06	0.08	0.02	0.02	0.05	0.05				0.06						

* Generalized presentation of data.
1/ FWPCA STORET, 1968.

waters is usually less than 3.0°/oo. The maximum salinity (about 33°/oo) for most areas of the Sound occurs in mid-August in response to the maximum intrusion of oceanic water into the Strait of Juan de Fuca. But the maximum surface salinity (about 31°/oo on the average) does not occur until fall when the freshwater contribution from the rivers has decreased to its lowest point. Minimum salinities are observed in winter, with a low of about 29°/oo at the surface and 31°/oo at depth.

Surface temperatures vary from an average low of about 44° F. (7° C.) in winter to about 52° F. (11° C.) in summer. The extreme temperatures range from a winter low of 38° F. (3° C.) and a summer maximum of over 68° F. (20° C.) in areas of restricted circulation. The deep-water temperatures are more stable, varying from 44° F. to 52° F. (7° to 11° C.). Rarely does the vertical temperature difference in the water column exceed 4° F. (2.2° C.), and it is usually less than 1° F. (0.6° C.).

Oxygen content varies from an average maximum of nine mg/l in the winter to an average minimum of five mg/l in the summer. The oxygen content of Puget Sound waters is usually above five mg/l at all depths. The dissolved oxygen content of the surface waters undergoes final diurnal fluctuation because of phytoplankton activity. The resulting oxygen production by the phytoplankton may cause the oxygen content to exceed 19 mg/l in some areas, with values of 9 to 11 mg/l being common over the entire Sound.

Surface phosphate content is also quite variable and ranges from nearly zero during the spring plankton bloom to over two microgram atoms per liter in the winter.

Because of biological activity in the surface waters of some areas like Lynch Cove in the Hood Canal, organic debris rains down into the lower layer. Since this organic debris has a high oxygen demand, the oxygen content of the deeper waters may often be less than 0.2 mg/l, while the phosphate content increases to more than four microgram atoms/l. Under proper wind conditions, this low-oxygen-content water may come to the surface, causing fish kills. This is a natural phenomenon and is not associated with any industrial or domestic wastes discharged into Puget Sound.

The surface-water characteristics of some areas of the Puget Sound are modified to some extent by effluent from pulp mills and other wastes from industries and municipalities. The deep waters off Everett Harbor are influenced somewhat by a submerged outfall serving two pulp mills. As the effluent is discharged, it mixes with the seawater and forms a thin layer below the surface. This layer is characterized by high sulfite waste liquor content (between 100 and 300 mg/l) and relatively low oxygen content.

The water quality of Bellingham and Port Angeles Harbors is also modified by the effluent from pulp mills in the vicinity which are a source of spent sulfite waste liquor (SWL).

Summary of Problems

A graphical summary of water quality problem areas in the Puget Sound Subregion is shown in figure 108. In general, serious water quality degradation has resulted from the discharge of inadequately treated municipal and pulp and paper mill wastes. Land runoff, in combination with municipal wastes, has resulted in eutrophic conditions in several lakes.

Studies for the Puget Sound Enforcement Conference have shown that pulp and paper mill effluents in Bellingham Bay, Everett Harbor, and Port Angeles Bay caused damage to the indigenous marine life by injuring juvenile salmon migrating through the harbors, by suppressing phytoplankton activity, by damaging oyster larvae and growth, by damaging bottom fish eggs, by damaging bottom organisms, and by producing overall unattractive aesthetic conditions.

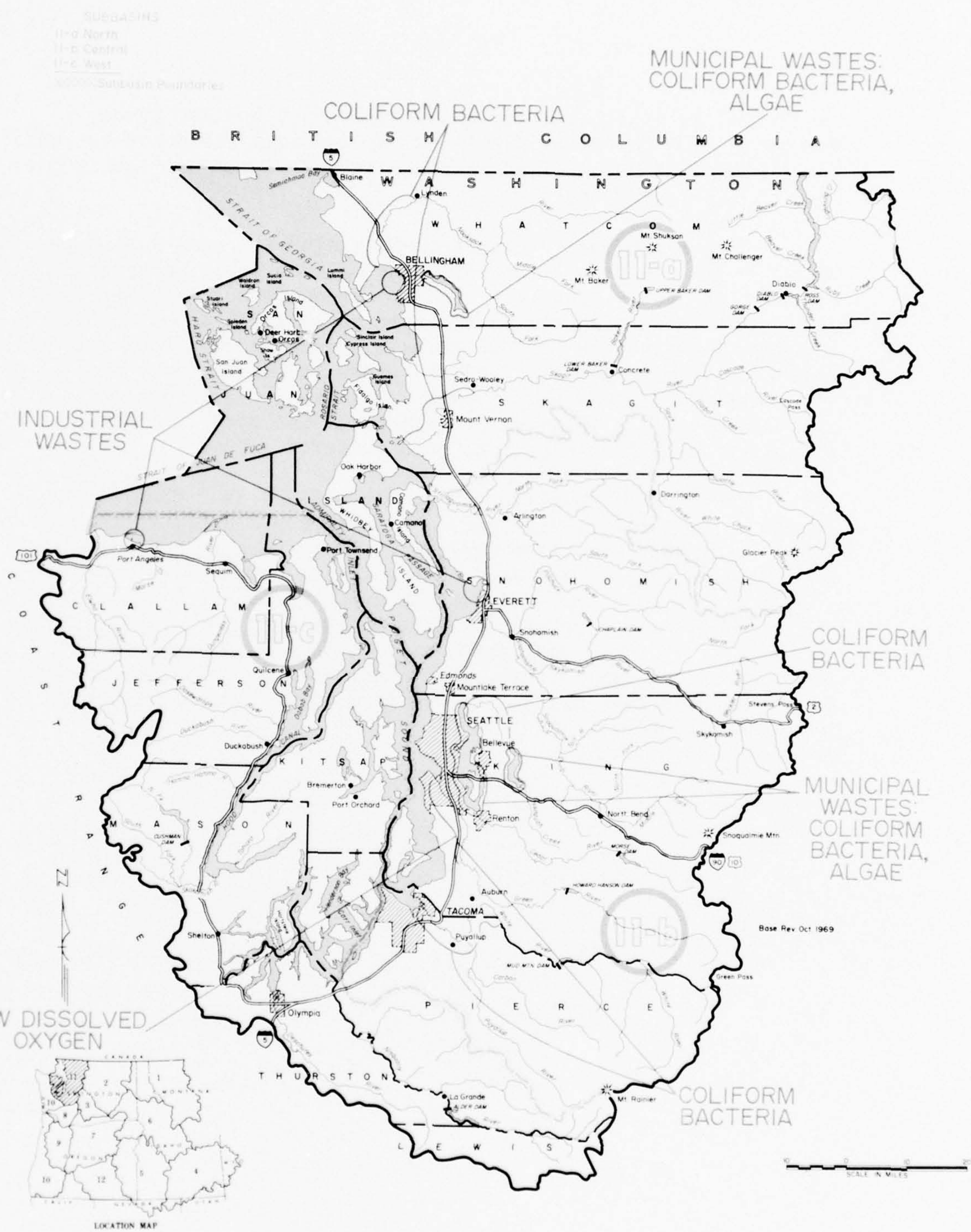
The lower reaches of the Puyallup, Duwamish, Nooksack, Skagit, White, and Sammamish Rivers; and Issaquah, Boise, Flett, Leach, and Chambers Creeks exhibit coliform densities above the limit recommended for safe water-contact recreation. In addition, the Duwamish River suffers from a dissolved oxygen deficiency during the summer low streamflow period.

Lakes Washington, Sammamish, Green, and Whatcom have been adversely affected by municipal waste loadings and by flow and land management practices, which have resulted in bacterial contamination as well as excessive nutrient enrichment of the lakes, causing excessive algal activity.

FUTURE WATER QUALITY MANAGEMENT NEEDS

Based on the projected economic development of the Puget Sound Subregion, the population is expected to increase from 1,972,700 in 1965 to 6,950,800 in 2020. This is an increase of over 250 percent for the subregion, compared with an increase of 121 percent for the entire Region.

Figure 109 shows the projected subbasin populations for the years 1980, 2000, and 2020. The projected subbasin and service area populations for municipal and rural categories are presented in table 148. By 2020, nearly 85 percent of the subregion's



COLUMBIA–NORTH PACIFIC
COMPREHENSIVE FRAMEWORK STUDY

MAJOR WATER QUALITY PROBLEM AREAS

PUGET SOUND SUBREGION 11

1970

FIGURE 108

population is expected to be located within the Cedar-Green, Snohomish, and Puyallup Subbasins. The municipalities of Everett, Seattle, and Tacoma now and in the future will compose the largest megalopolis in the Region.

Future economic growth to 1980 includes a number of highlights. Employment will approach one million jobs, and gross subregional product will almost double. Production growth for the major water-using industries is expected to realize an 82 percent increase from 1965 to 1980 in terms of value added. Food and kindred products, paper and allied products, and primary metals are projected to lead this growth. Relatively large increases are also projected for chemical and petroleum industries. On the declining side is the lumber and wood products industry.

The northern portion of the Puget Sound Subregion is projected to show the largest increase in economic activity through 1980. Aluminum, petroleum refining, and university and research facilities will lead the way. The pulp and paper industry and the wood products industry will also expand. In the central portion, the aerospace industry will provide the driving force. Noticeable declines in economic activities will be felt in lumber and wood products and in agriculture, where land will be converted to urban uses. Major growth in the western part will stem from the pulp and paper industry.

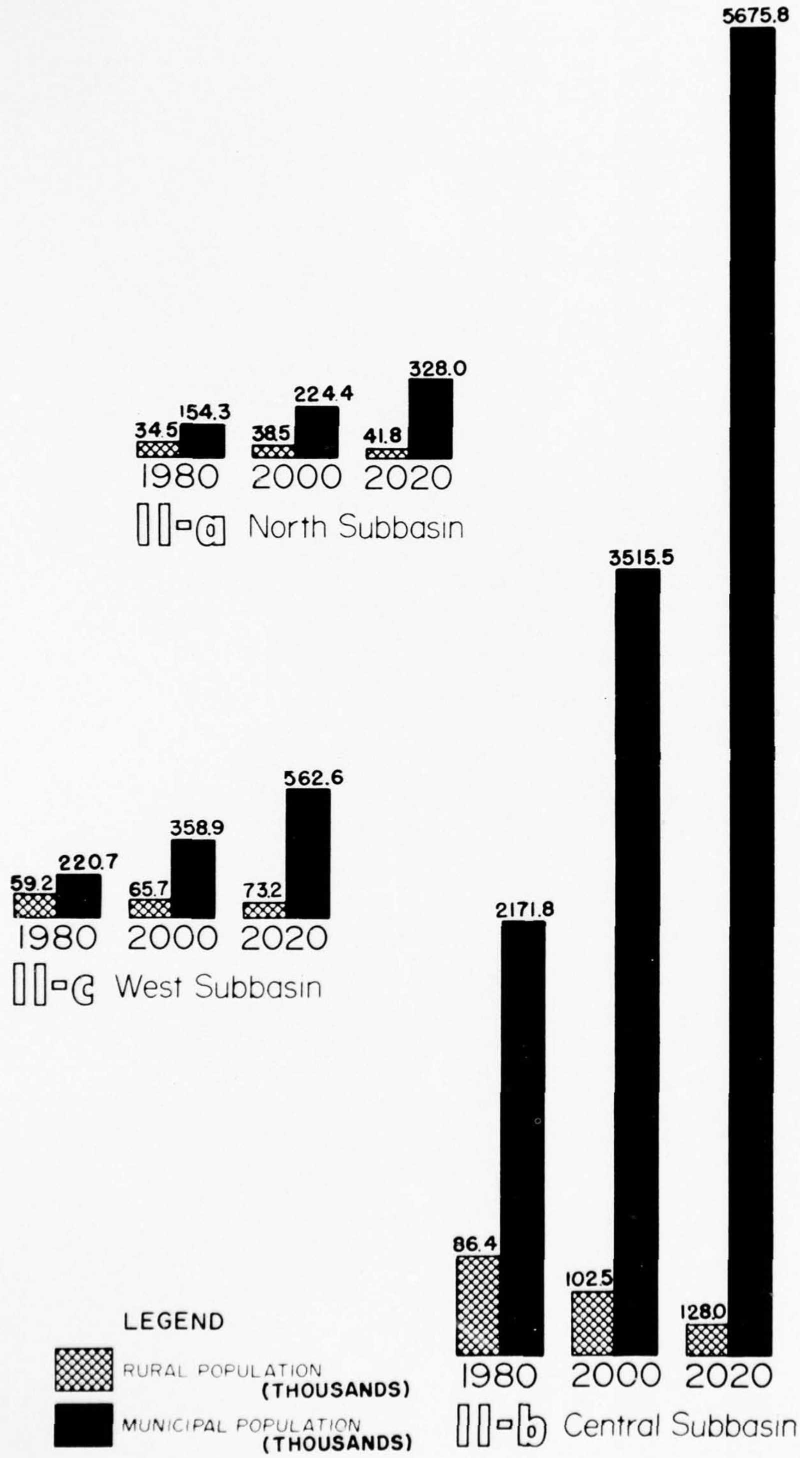


FIGURE 109. Projected Population, Subregion 11

Table 148 - Projected Population, Subregion 11 (11)[1/]

	1980	2000	2020
	----------Thousands----------		
North Subbasin	188.8	262.9	369.8
Bellingham Service Area	55.0	75.0	100.0
Municipal	50.0	72.5	100.0
Rural	5.0	2.5	---
Other	133.8	187.9	269.8
Municipal	104.3	151.9	228.0
Rural	29.5	36.0	41.8
Subtotal	188.8	262.9	369.8
Municipal	154.3	224.4	328.0
Rural	34.5	38.5	41.8
Central Subbasin	2,258.2	3,618.0	5,803.8
Everett Service Area	180.0	250.0	450.0
Municipal	180.0	250.0	450.0
Rural	---	---	---
Seattle Service Area	1,271.0	2,079.9	3,419.7
Municipal	1,271.0	2,079.9	3,419.7
Rural	---	---	---
Tacoma Service Area	411.3	570.6	730.0
Municipal	411.3	570.6	730.0
Rural	---	---	---
Other	395.9	717.5	1,204.1
Municipal	309.5	615.0	1,076.1
Rural	86.4	102.5	128.0
Subtotal	2,258.2	3,618.0	5,803.8
Municipal	2,171.8	3,515.5	5,675.8
Rural	86.4	102.5	128.0
West Subbasin	279.9	419.6	635.8
Olympia Service Area	35.0	47.0	67.0
Municipal	35.0	47.0	67.0
Rural	---	---	---
Bremerton Service Area	70.0	116.7	169.5
Municipal	70.0	116.7	169.5
Rural	---	---	---
Other	174.9	255.9	399.3
Municipal	115.7	190.2	326.1
Rural	59.2	65.7	73.2
Subtotal	279.9	419.6	635.8
Municipal	220.7	353.9	562.6
Rural	59.2	65.7	73.2
Total Subregion	2,726.9	4,300.5	6,809.4
Municipal	2,546.8	4,093.8	6,566.4
Rural	180.1	206.7	243.0

1/ The municipal population is defined as that population discharging wastes to a municipal sewerage system. The rural population is defined as the residual.

Future Waste Production

Municipal

The projected municipal raw waste production for the Puget Sound Subregion is presented in table 149. The population served by municipal waste collection and treatment systems is expected to increase from 53 percent in 1965 to 96 percent by the year 2020. It has been assumed that the entire populations of the Everett, Seattle, and Tacoma Service Areas will be served by municipal systems at that time. These service areas will account for 70 percent of the raw municipal waste production in 2020, as compared with 75 percent at the present time. The Seattle Service Area alone will account for 52 percent of the total raw municipal waste production for the subregion.

Table 149 - Projected Municipal Raw Organic Waste Production Subregion 11 1/

	1970 2/	1980	2000	2020
		(1,000's	P.E.)	
North Subbasin	117.6	192.9	280.5	410.0
Bellingham Service Area	79.5	62.5	90.6	125.0
Other	38.1	130.4	189.9	285.0
Central Subbasin	1630.3	2714.8	4,395.0	7,094.7
Everett Service Area	135.1	225.0	312.5	562.5
Seattle Service Area	954.1	1588.8	2,599.9	4,274.6
Tacoma Service Area	308.8	514.1	713.2	912.5
Other	232.3	386.9	769.4	1,345.1
West Subbasin	181.5	275.9	442.5	703.3
Olympia Service Area	28.9	43.8	58.8	83.8
Bremerton Service Area	57.5	87.5	145.9	211.9
Other	95.1	144.6	237.8	407.6
Total Subregion	1929.4	3,183.6	5,118.0	8,208.0

1/ A factor of 1.25 was applied to the municipal population components to account for the effects of small commercial establishments and other urban activities which add to municipal waste loads.
2/ Interpolated from 1965 data and 1980 population projections.

Industrial

Projected raw organic waste loadings for the major industrial categories are presented in table 150. By the year 2020, it is expected that industries will account for nearly 70 percent of the total organic waste production for the entire subregion. The

pulp and paper industry will continue to be the largest source of organic wastes, contributing approximately 60 percent of the total industrial waste production.

Table 150 - Projected Industrial Raw Organic Waste Production
Subregion 11 (11) 1/

	1970	1980	2000	2020
		(1,000's P.E.)		
Pulp and Paer	12,821	12,868	12,270	11,224
Food Products	1,449	2,065	4,095	7,560
Lumber and Wood Products	31	34	33	28
Other	33	41	56	74
Total	14,334	15,008	16,454	18,886

1/ Industrial raw waste production derived from growth indices, with consideration given to expected changes in in-plant processes and technology.

In general, increases in waste production are expected to occur at existing operations for most industries. The lumber and wood products industry, however, is expected to decrease somewhat by 2020.

Rural-Domestic

The projected rural-domestic waste production is summarized in table 151. The rural-domestic waste production was assumed to be equal to the rural population component shown in table 148. For all three subbasins, the rural-domestic waste production is expected to increase somewhat in future years.

Table 151 - Projected Rural Domestic Raw Organic Waste Production
Subregion 11

	1970 1/	1980	2000	2020
		(1,000's P.E.)		
North Subbasin	59.4	34.5	38.5	41.8
Central Subbasin	525.3	86.4	102.5	128.0
West Subbasin	95.9	59.2	65.7	73.2
Total Subregion	680.6	180.1	206.7	243.0

1/ Interpolated from 1965 data and 1980 projections.

Irrigation

About 91,700 acres are presently irrigated in the Puget Sound Subregion. The Nooksack-Sumas Subbasin contains the most irrigated lands--more than 38,000 acres. The amount of water diverted for irrigating the 91,700 acres is estimated to be 227,500 acre-feet annually, less than 0.5 percent of the runoff of the subregion. Irrigation expansion in the future is projected to be relatively modest. The location and extent of suitable land are the primary limiting factors. Projected acreages are 138,100 by 1980, increasing to 223,100 acres by 2020. Irrigation practices are not now considered a significant source of wastes in the Puget Sound Subregion and in future years, through increased efficiency of application, irrigation should be even less of a pollution source.

Some of Puget Sound's cropland receive fertilizers at rates heavier than those normally used in other parts of the state. This is illustrated by the fact that the 3.1 percent of the state's farmland which is located in the Puget Sound Subregion received 12 percent of the total fertilizer reportedly used in the state in 1964. Even with large amounts of fertilizers being applied, little is leached or washed away in the surface waters. The increased use of fertilizers does, however, represent a significant potential source of nutrients which, with proper application procedures, should not cause water quality problems.

Agricultural Animals

Farm animals produce large amounts of waste. It has been estimated that the waste produced by one cow is equivalent to that produced by about 6.4 persons. Most of this waste produced in Puget Sound remains on the land, but rain and irrigation waters flush part of it into streams and ponds. Dairies, feedlots, and other animal concentrations along streams cause erosion as well as intensifying the potential coliform bacteria, nutrients, and biochemical oxygen demand in the water.

The raw organic waste production by the livestock population in the subregion is expected to be equivalent to that from a population of 3,800,000 persons in 1980; 5,000,000 in 2000; and 6,600,000 in 2020. This would account for approximately 20 percent of the total raw organic waste production for the subregion by 2020. The percentage of cattle on feedlots is expected to increase by the year 2020, which will further concentrate the wastes from this source.

Other Land Uses

Projections of land use in the subregion, by major types, are shown in table 152.

Table 152 - Projected Land Use, Subregion 11 (5) (8)

Land Use	1966(L)	1980	2000	2020
		(1,000's P.E.)		
Cropland	591	470	403	385
Irrigated	(92)	(134)	(180)	(216)
Nonirrigated	(499)	(336)	(223)	(169)
Forest	6,429	6,419	6,336	6,189
Range 1/	105	105	100	92
Other 2/	1,322	1,433	1,576	1,737
Total	8,447	8,427	8,415	8,403

1/ Does not include forest range.
2/ Includes barren land, roads, railroads, small water areas, urban and industrial areas, farmsteads, airports, etc.

The projections show a decrease in land area of approximately 35 percent for cropland and 13 percent for forest by the year 2020.

The number of farms will also be reduced 40 percent by 1980 and 66 percent by 2020. Future declines in the amount of farmland will be associated with urban population growth and industrial expansion. Agriculture will have its greatest decline in the central part of the subregion, where over 30,000 acres are expected to be converted to urban uses by the year 2020. With this conversion, there is potential for erosion and stream damage as the lands are developed.

Constituents carried in the water draining from agricultural land could result in significant water quality degradation. The urban dwellers as well as the farmers of the area use large amounts of petroleum products, fertilizing minerals, and toxic substances such as organic and inorganic insecticides and herbicides. The amounts of these substances are expected to increase in the future, since the proportion of farmland used for crops or pasture is expected to increase substantially.

Recreation

As shown in table 153, wastes generated by recreational activity are projected to increase to 1,351,800 PE by 2020--more than six times present levels. These wastes, however, will account for only 6 percent of the cotal wastes produced in the subregion.

Table 153 - Recreation Wastes, Subregion 11 1/

Year	Population Equivalents
1970	262,600
1980	360,800
2000	696,800
2020	1,351,800

1/ Bureau of Outdoor Recreation and U.S.D.A. Forest Service Projections for total man recreation days (TMRD).

In the determination of wastes from recreation activities, the population equivalent is based on the total annual recreation day. The above values represent the daily raw waste production for a typical summer weekend.

Other Factors Influencing Water Quality

Dredging normally is carried out in the estuarine areas where sediment and waste products build up to block navigable waters. In areas where new port facilities are being constructed, dredging is usually a prerequisite.

Dredging introduces quantities of suspended material to the local water prism. In those bottom areas where debris and sludge beds have built up from industrial waste discharges, dredging frees large quantities of oxygen-demanding organics in the water and may release toxic products of decomposition. In Puget Sound, dredging is an important activity. The primary effect on water quality has been high turbidity.

At the present time, the mining of heavy metals is limited in the Puget Sound Subregion. Economic conditions have caused most of the existing mines to be closed. There are several areas were limestone is mined for use in pulp mills or in the manufacture of cement, but no water quality problems have arisen from this activity. Coal is being mined to a limited extent in two locations in the Puget Sound Subregion. Many other large deposits exist, but the market does not justify the mining of these deposits. Although there has been some water pollution in the past from coal mining operations, this problem has been eliminated.

Few effects on water quality have been documented for the 24 major reservoirs in the subregion. Ross Dam has little effect on the temperature regime of the downstream reaches of the Skagit River. Probably the most significant adverse effect has been on the White River, tributary to the Puyallup. Mud Mountain Dam is

operated as a single-purpose flood control structure, storing the winter and spring floods which carry substantial suspended material from upstream glaciers. To prevent a buildup of this material in the reservoir, it is flushed out each fall. This introduces a large slug of sediment to the White River during the low-flow period, seriously degrading the winter quality. This operational procedure is undergoing review to find a means which will achieve the same results without the severe impact to water quality.

Lake Whatcom receives inflows diverted from the Middle Fork of the Nooksack River, which contains large sediment loads of glacial origin. There has been no noticeable effect upon the lake from suspended material, but study is continuing to discern any adverse trend that may develop.

Control of waste heat produced by thermal nuclear power plants will be important in the maintenance of adequate water quality. For all proposed power plant locations, special studies will be required to determine treatment or controls necessary for protection of temperature in receiving waters. With the future outlook for nuclear power plant development one of considerable growth, the potential threat to water quality--and in particular to the ecological balance of Puget Sound waters--is great. Sites located on fresh waters will require adequate facilities for proper control of waste heat discharges to prevent adverse quality and ecological effects on the rivers.

Streamflow management can also have an impact on water quality. When streamflows diminish, water quality suffers. Management programs reflect the public's attitude, and achievement of good water management and the flows needed can be realized only with the support of the people, informed and aware of the problems and their solutions.

Quality Goals

The water quality goals discussed in this section represent the levels of water quality required to fully support water uses. In managing the subregion's water, the primary purpose is to protect or enhance the quality and value of the water resources and to establish regional programs for the prevention, control, and abatement of water pollution to allow maximum use of the resource for all beneficial purposes.

Under the Water Quality Act of 1965 quality standards for interstate and coastal waters and a plan (22) for implementation and enforcement of such standards were established by the State of Washington and approved by the Secretary of Interior. Their

primary purpose is to protect high quality waters and upgrade polluted ones. They also provide additional tools for making objectives and clear public policy statements on the orderly development and improvement of the water resources.

Washington has also developed water quality standards for intrastate waters which are consistent with the interstate standards. These interstate and proposed intrastate standards are the basis for the water quality goals in this study.

Each stream was classified as to its intended use, including agricultural, municipal, industrial, recreational, fish and wildlife uses, and the water quality standards to support each use include not only the criteria or levels of quality necessary but also plans to implement and achieve these levels of quality. In addition, the standards incorporate an anti-degradation provision by requiring that waters whose existing quality is better than the established standards be maintained at the existing higher quality level. The parameters used in the criteria are means of measuring water quality. The common parameters generally used are dissolved oxygen, temperature, turbidity, and coliform density.

All activities which discharge wastes into the waters or affect water quality must provide all known available and reasonable methods of treatment and control. For these locations in the Puget Sound Subregion, which are referred to in the implementation plan, the general policy regarding waste treatment was that the proposed interstate standards would require secondary treatment unless it could be shown that a lesser degree of treatment could be utilized without violation of the standards. With approval of the interstate standards by the Secretary of Interior, exceptions have been made to allow primary treatment with adequate outfalls and disposal area evaluations for plants at several cities, including the major cities of Seattle, Tacoma, Port Angeles, and Anacortes, with the provision that additional treatment would be required if water quality standards were violated. The water quality standards for interstate and coastal waters are summarized in table 154.

The above uses and criteria are not inclusive, and the water quality standards should be consulted for specific information. A copy of the water quality standards is available upon request from the Washington Department of Ecology.

Table 154 - Water Quality Classification and Criteria, Subregion 11

	WATER QUALITY STANDARDS							
	Class AA Extraordinary		Class A Excellent		Class B Good		Class C Fair	
Parameters	Fresh	Marine	Fresh	Marine	Fresh	Marine	Fresh	Marine
Coliform (MPN)	50	70	240	70	1,000	1,000	1,000	1,000
Dissolved Oxygen (mg/l)	9.5	7.0	8.0	6.0	6.5	5.0	5.0	4.0
Temperature* (°F.)	60	55	65	61	70	66	75	72
pH	6.5-8.5	7.8-8.5	6.5-8.5	7.8-8.5	6.5-8.5	7.8-8.5	6.0-9.0	7.0-9.0
Turbidity (JTU)	5	5	5	5	10	10	10	10
Toxicity**	Shall be below those of public health significance, or which may cause acute or chronic toxic conditions to the aquatic biota, or which may adversely affect any water use.							
Aesthetic Values	Shall not be impaired by the presence of materials or their effects, excluding those of natural origin, which offend the senses of sight, smell, touch, or taste.							

* For all classes, the permissible increase in temperature over natural conditions is less than 1.8° F.
** Exact definitions of toxicity can be found in the Water Quality Standards.

MEANS TO SATISFY DEMANDS

Most of the present and future needs in Puget Sound will be met if adequate waste treatment facilities required in the present and proposed quality standards are installed at all municipal, industrial, and recreational areas. This will reduce the amount of residual wastes entering fresh and marine waters to levels within their assimilative capability. It will also require substantial new waste treatment construction in the near future, especially by the pulp and paper industry. Ports will need to provide hookup facilities for commercial vessels, and recreation sites will have to have adequate facilities for people and recreation watercraft.

Major streams where flows may be inadequate in future years are the Cedar and Green Rivers. A potential conflict exists on the Cedar River between future municipal water supply diversions and the need for flushing inflows to Lake Washington. A detailed study and development of information systems including computer models, however, should be undertaken to determine flows required for this purpose and potential sources of supply. Increased future diversions from the Green River by the city of Tacoma may also conflict with required flows for water quality control in the Green-Duwamish River.

Ultimately, the achievement and preservation of good water quality are based upon people operating within the context of a political, social, and economic system. The attainment of adequate

water quality in Puget Sound will require an efficient, adequately staffed and funded water quality management system geared for attacking the water pollution problem.

Waste Treatment

Future Waste Discharges

Adequate waste collection and treatment facilities are the primary means for achieving desired water quality objectives in the Puget Sound Subregion. Although other elements are also necessary, installation of adequate waste treatment facilities is considered to be prerequisite.

The required waste collection and treatment facilities will be the major tool in attainment of adequate water quality. They do not, however, guarantee water quality improvement but represent only the initial requirements. If additional requirements and actions become necessary to attain desired quality levels, the standards and implementation plan will have to be revised accordingly. In addition to the standards for marine and esturial waters, the establishment of intrastate water quality standards which are not being formulated for the fresh waters will aid in quality attainment in these locations.

For purposes of the Type 2 Puget Sound Study, residual wastes following treatment were computed using secondary treatment efficiencies of 85 percent for 1980 and 2000, and 90 percent for 2020. Primary treatment efficiencies on discharges to marine waters were assumed to be 35 percent for 1980 and 2000, and 40 percent for 2020 to reflect more advanced equipment and processes. In some cases it may be practical to provide higher degrees of waste treatment for removal of residual organic materials and nutrients. These treatment levels result in a much higher discharge than those based on the Type 1 criteria of 85% efficiency in 1980 and 90% in 2000 and 2020.

Based on Type 1 and Type 2 treatment levels and raw waste projections presented earlier, the projected municipal and industrial organic waste loadings are presented in table 155.

Table 155 - Projected Municipal and Industrial Organic
Waste Discharges, Subregion 11

Subbasin	1980	2000	2020
		(1,000's P.E.)	
Based on Type 2 Criteria:			
North	1,161.5	1,425.6	1,529.4
Municipal	88.5	120.4	149.8
Industrial	1,060.1	1,280.0	1,351.9
Recreation	12.9	25.2	27.7
Central	3,405.3	4,854.5	6,215.1
Municipal	1,623.9	2,696.8	3,991.3
Industrial	1,754.3	2,106.3	2,161.0
Recreation	27.1	51.4	62.8
West	1,193.5	1,671.5	1,942.3
Municipal	158.6	267.5	379.4
Industrial	925.1	1,201.8	1,249.9
Recreation	109.8	202.2	313.0
Based on Type 1 Criteria:			
Municipal	477.5	511.8	820.8
Industrial	2,251.2	1,645.4	1,888.6
TOTAL	2,728.7	2,157.2	2,709.4

Treatment Costs

Curves showing estimated costs of constructing (total capital) and operating (annual operation and maintenance) municipal sewage treatment plants for various treatment levels are presented in the "Means to Satisfy Demands" section of the Regional Summary.

Other Pollution Control Practices

Considerable future development of thermal power plants is expected in the Puget Sound Subregion. With this development, large amounts of waste heat will be generated which could cause serious water quality degradation without the application of adequate control methods. With potential sites for thermal power plants being located on both the fresh and marine waters of the Puget Sound Subregion, control of waste heat may be accomplished by different means.

For those plants to be located in the vicinity of Puget Sound, evaluation of sites must involve detailed biological, oceanographic, and water quality assessment acceptable to the involved Federal and State agencies before selection and acquisition of nuclear power plant sites.

For those thermal power sites located on the fresh-water streams, once-through cooling should not be allowed in the control of water quality. Cooling towers or possibly lagoons may need to be employed to adequately reduce the amounts of waste heat discharged.

Table 156 - Minimum Flow Requirements (cfs), Subregion 11

River	1980	2000	2020	One-in-Ten-Year Low Flow
Nooksack	180	350	725	760
Skagit	240	435	650	5,100
Stillaguamish	20	30	40	330 1/
Snoqualmie	10	20	25	450
Skykomish	150	285	335	490
Snohomish	400	750	890	9,500 2/
Puyallup near Puyallup	105	245	270	910
White	45	120	135	340
Puyallup near Tacoma	140	210	240	910
Nisqually	30	50	60	405

1/ Combination of North and South Forks near Arlington. Flow requirements are based on land application of industrial wastes.
2/ Mean annual flow.

The control of oil pollution is now important to water quality and is expected to become more important in the future. Control of this widespread pollutional source will involve finding an adequate, legal method of disposal coupled with an effective prevention-oriented oil pollution control program. Collection systems aboard ships and offshore collection and disposal facilities must be provided if oil pollution is to be prevented. Further control involves implementation of an efficient system for reporting and collecting accidental spills.

Disposal of watercraft wastes--trash, garbage, debris, sewage, oil, and gasoline--directly to the waters without treatment is presently a common practice. The control of such wastes will largely depend on legislation prohibiting the discharge of raw sewage, garbage, or trash or debris by requiring these wastes to be retained in holding tanks for disposal on shore or on the high seas.

A monitoring network for the estuaries and marine waters of Puget Sound has been developed as specified in the implementation plan. Adequate decisions concerning waste management and water quality require a basic knowledge of the water characteristics. While a number of Federal, state, and local agencies and universities are actively involved in the monitoring of water quality in certain locations of the Puget Sound Subregion, the overall water quality characteristics of the marine waters are not adequately defined.

A basic network for fresh-water areas exists. It requires some expansion now and will undergo readjustments in the future as the conformation of waste sources changes. Similarly, the parameters measured will be adapted to the needs. A basic network should be established for ground water.

Recreation areas will be increasing in number throughout the subregion. Sewage disposal systems adequate to cope with weekend loads from use by thousands will be needed in many recreation areas.

Minimum Flow Requirements

Since waste treatment does not provide complete removal of contaminants from waste streams, some streamflow is necessary for assimilation of residual wastes. Virtually all streams near the Sound require some flow to absorb the wastes expected to be discharged to them. In the future, with the heavy development of recreation in the headwaters of the basins creating residual wasteloads there, it will even be necessary to maintain adequate levels of flows in those presently remote areas. Present streamflows during the summer low-flow period exceed flow requirements for waste assimilation in most rivers.

It should be noted, however, that the flow requirements are based upon a presumed settlement pattern and assumed industrial development locations. These, as previously noted, were primarily extensions of the present patterns and would result in the minimum impact on the streams and rivers. Should extensive urban shifts to inland areas occur, such as along the Snoqualmie or Stillaguamish Rivers, the flow requirements would be markedly increased. Again, these contingencies were not investigated nor built into the plans. The recommended minimum flow requirements, as presented in table 156, do present a reasonable approximation to maintain adequate future water quality in the face of the projected growth, presuming the planned waste treatment facilities are constructed. Flows presented in table 156 are primarily for downstream reaches. The low flow expected once in ten years is also presented.

Management Practices

At the present time, the state occupies a strategic position in water quality management. It is the focal point and has the primary responsibility for water pollution control. The ability of the pertinent state agencies to discharge their responsibilities must be strengthened in order to enhance the effectiveness of their roles in water quality management by engineering and planning developments.

Stronger land use controls and other associated controls must be developed: (1) that give significant attention to the physical capabilities of the fresh and marine waters and (2) that give protection to the various uses of water. This will require a combination of actions, including the regulation of urban and industrial development, maintenance of control over densities, and narrowing of the range of permitted uses to be compatible with, and complementary to water quality and primary water use objectives.

Zoning can be a useful tool to preserve water quality and to protect the uses of water, provided that such regulations are prepared in conjunction with a carefully worked out policy or comprehensive plan and that their application bears a substantial relationship to the health, safety, or general welfare of the public.

The poor flushing and dispersion characteristics of marine water in some areas indicate that the location of new industry must be constrained so as to minimize its adverse effect on water quality. Transport characteristics of marine waterways in South Puget Sound and Hood Canal are weak and poorly defined. Such bays as Port Susan, Skagit, Samish, and Padilla exhibit poor flushing. Other local areas have limited waste dispersion capabilities, suggesting that future wasteloads must be kept to a minimum in these areas. By the same token, areas with good water movement and replacement, air movements, and other attributes should be indicated as good industrial sites and the way paved for their development as such.

LOCATION MAP

SUBREGION

12

SUBREGION 12

OREGON CLOSED BASIN

INTRODUCTION

The Oregon Closed Basin Subregion (figure 110) encompasses the high Central Oregon plateau with internal drainage into land-locked lakes. The subregion is sparsely populated and is essentially in a natural condition--relatively undisturbed by man's activities.

Few important pollution sources exist in the closed basin. Municipal waste sources produce wastes totaling about 4,500 population equivalents. Industrial organic waste production by lumber mills is considered insignificant. Irrigation practices and agricultural animals are significant sources of pollution.

The natural setting of the area is the most critical factor affecting water quality. As a result, the streams are uniformly of high water quality. However, evaporation in the numerous shallow lakes with large surface areas has resulted in brackish water conditions in the terminal water bodies.

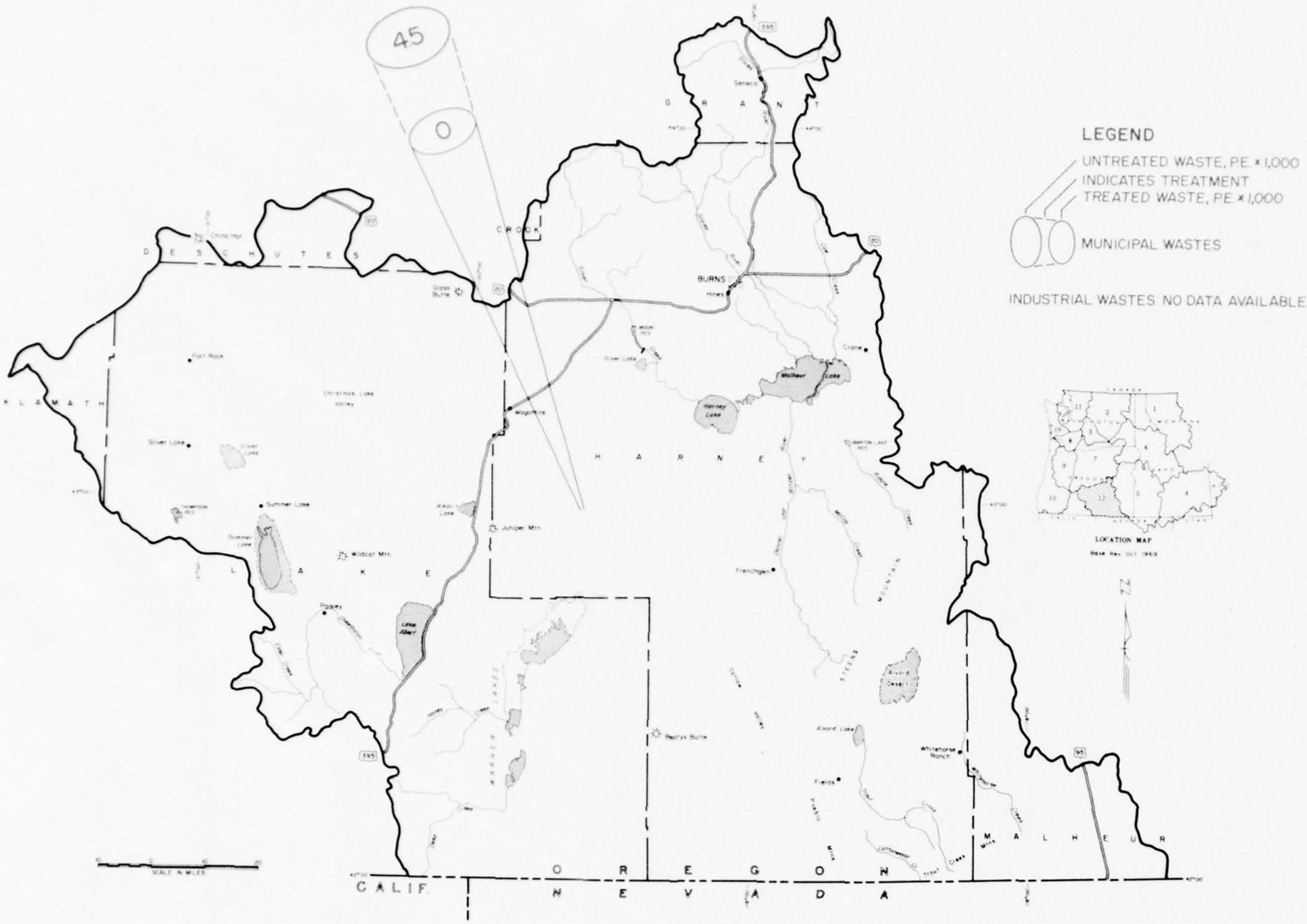
PRESENT STATUS

Stream Characteristics

The principal streams are the Silvies River, draining the northeast portion of the closed basin; the Donner and Blitzen River, draining the west side of the Steen Mountains; and Silver Creek, Chewaucan River, and Deep Creek, draining the west side of the closed basin.

The surface waters do not reach the sea but form interior drainages. The rivers flow from the mountains and lose themselves in the valley floor, or they flow into one of the several lakes, the largest of which are Malheur Lake, Harney Lake, Lake Abert, Summer Lake, and Silver Lake.

Average annual runoff generated within the subregion is about 1,650 cfs (1.19 million acre-feet). This provides an average runoff of 0.09 cfs per square mile.



COLUMBIA-NORTH PACIFIC
COMPREHENSIVE FRAMEWORK STUDY

MUNICIPAL AND INDUSTRIAL WASTES BY SUBBASIN

OREGON CLOSED BASIN
SUBREGION 12

1970

FIGURE 110

Surface-Water Hydrology

The seasonal variation in runoff in the west-side streams is generally characterized by two peaks, one during winter (usually December) and a larger one in the spring (generally April or May). The east-side streams have only one peak, which occurs in the spring (usually April or May). Table 157 presents average monthly discharge data for selected stations. The period of low runoff most often occurs between the months of July and November. One-in-ten-year low flows are used to predict recurrence frequency of critical low flows. These data are summarized in table 158.

Table 157 - Mean Monthly Discharge, Subregion 12 (12)

Stream and Location	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
							(CFS)						
Deep Creek above Adel, Oregon	52	87	165	411	387	183	26	9	10	17	27	61	120
Honey Creek near Plush, Oregon	8	16	37	94	85	37	4	1	0	2	3	9	25
Chewaucan River near Paisley, Oregon	66	91	150	366	487	243	56	27	28	36	44	74	139
Silver Creek near Silver Lake, Oregon	8	12	22	75	65	29	20	6	5	5	4	7	22
Silvies River near Burns, Oregon	51	132	305	800	414	129	27	10	9	16	28	44	164
Donner and Blitzen River near Frenchglen, Oregon	59	84	116	218	341	252	84	40	37	46	51	59	116
Trout Creek near Denio, Nevada	6	7	12	33	60	32	8	3	3	5	6	6	15

Table 158 - One-in-Ten-Year Low Flows, 1/ Subregion 12 (12)

Stream and Location	One-in-Ten-Year Low Flow (cfs)
Deep Creek above Abel, Oregon	<5
Honey Creek near Plush, Oregon	0
Chewaucan River near Paisley, Oregon	11
Silver Creek near Silver Lake, Oregon	<1
Silvies River near Burns, Oregon	<5
Donner and Blitzen River near Frenchglen, Oregon	20
Trout Creek near Denio, Nevada	1.1

1/ Period of 1 month.

Impoundments and Stream Regulation

There is only one major reservoir in the subregion. Thompson Reservoir, which has a total capacity of 21,500 acre-feet, is operated for the purpose of storing water for irrigation. There are several major lakes in the closed basin, but none are regulated. However, flows from a number of major tributary streams are partially diverted to irrigation canals.

Ground-Water Characteristics

Subregion 12 is underlain largely by alluvial deposits and volcanic and sedimentary rocks of Miocene or younger age that are capable of yielding moderate to large supplies at many places. Permeable aquifers are perhaps more widespread than in any other subregion. However, the availability of ground water is limited by the depth to the water, which is more than 500 feet over considerable areas, and is more than 1,000 feet at some places. Also, the annual recharge is small in comparison with most other subregions.

Ground-water quality is generally poorer than in other subregions; however, dissolved solids commonly are less than 1,000 mg/l. Excessive sodium, boron, and fluoride cause problems at places. Ground-water temperatures generally range from about 47°F. (8.3°C.) to 55°F. (12.8°C.), but some wells yield warm to hot water. Subregion 12 contains the greatest concentration of thermal springs of any part of Oregon.

Pollution Sources

A summary of municipal waste treatment facilities is presented in table 159.

Table 159 - Summary of Municipal Waste Treatment Facilities, Subregion 12 1/

Municipal Discharge	Municipal Population Tributary to System	PE before Treatment	Treatment Facilities	Normal Waste Discharge PE
Burns, Oregon	3,500	3,500	Land, Lagoons	0
Hines, Oregon	1,000	1,000	Land	0

1/ FWPCA inventory of municipal and industrial wastes, Oregon Closed Basin, 1965.

At present, municipalities produce wastes equivalent to those from a population of 4,500 persons. The only major industries in the subregion are lumber mills which generate minor amounts of organic wastes.

Agricultural animal wastes are relatively important pollution sources. Wastes from the rural-domestic population, recreation, irrigation, other land uses, and natural sources are minor pollution sources.

Municipalities

Approximately 4,500 persons, or 34 percent of the Oregon Closed Basin Subregion's population, are served by municipal waste collection and treatment systems. The communities of Burns and Hines are the only municipalities providing waste treatment. Burns operates a waste stabilization pond and disposes of the waste water to land. The community of Hines practices land disposal of its domestic wastes. As a result, the waste load reaching streams is relatively minor. The small town of Seneca presently discharges untreated domestic sewage to Silvies River.

Industries

A lumber company at Hines is the only major industrial waste source. However, no data are available concerning the firm's waste production and treatment facilities. Seneca and Paisley also have lumber mills.

Rural-Domestic

About 8,800 persons, or 66 percent of the subregion's population, depend upon individual waste disposal systems. In general, septic tanks and some type of subsurface tile drains are utilized for waste disposal. The actual waste load reaching waterways is not considered to be large.

Irrigation

The irrigated land in the closed basin amounts to about 327,000 acres. Approximately 749,000 acre-feet of water are diverted or pumped annually to the fields. An estimated 44 percent of the applied water returns to streams or the ground water as irrigation return flow.

Irrigation is a relatively minor pollution source. However, flood irrigation, which is used extensively, is very inefficient and results in high sediment and silt loads during the irrigation season.

Agricultural Animals

Wastes from the large agricultural animal population represent a significant organic loading. The animal population produces an estimated waste load equivalent to that from a population of 1.3 million persons. Even if 95 percent of the waste load were removed by natural decomposition and soil action, about 65,000 PE would still eventually reach waterways.

Present Water Quality

Water quality in the Oregon Closed Basin Subregion has the distinction of being essentially in a natural condition. While the chemical quality is in some instances less than desirable, there is no use interference. In fact, the nutrient balance, coupled with the wet and dry extremes characteristic of the area, produces an ideal ecology for biological productivity and bird habitat.

Water quality data in the closed basin are sparse. Miscellaneous samples have been collected at various times at several locations. In addition, the Oregon State Department of Environmental Quality collects samples three times per year for several streams and lakes.

Oxygen levels are generally high and coliform densities low, as would be expected for a relatively unpopulated area. The Silvies River currently receives raw sewage from the town of Seneca; as a result, bacterial densities below the community are undesirable. Based on several samples, MPN's have ranged from 2,400 to 7,000 organisms/100 ml in this stretch of the river. The only low dissolved oxygen level in the subregion has been recorded in Lake Abert. However, considering the high chloride content of the lake (10,000 mg/l) and no appreciable coliform count, no sanitary problem appears to exist.

Sediment yield in the subregion is known to be small and is believed to be less than 0.1 acre-foot per square mile per year.

The surface streams of the area are similar in chemical composition to most of the streams of mountainous origin in the State of Oregon. The waters are primarily a calcium-magnesium bicarbonate type and are low in dissolved solids and hardness. The lakes into which these streams flow, however, differ greatly in chemical character from the tributary streams. This is an area of interior drainage in that the surface waters have no outlet to the sea but, rather, drain into the lower elevations to form shallow lakes with large surface areas.

Because of the volume change that takes place as a result of evaporation, the dissolved minerals in the lakes may be greatly concentrated. The mineral concentration of the lake water may become several hundred times that of the streams which flow into the lake. Several of these lakes contain water with a dissolved solids content in excess of 30,000 mg/l. In addition to the concentration of the lake water resulting from this change in volume, a change in chemical composition may also take place as a result of the precipitation of the less soluble minerals.

As the mineral concentration of the waters increases, calcium carbonate, being the least soluble, will precipitate out of solution first. If there still is calcium available in solution, gypsum (calcium sufate) will precipitate next. Sodium and chloride are much more soluble and will remain in solution. If bicarbonate is present in excess of calcium, as is the case in this subregion, considerable quantities of this ion will also remain in solution. The end result of this process is a very concentrated water, of which the dissolved solids content consists almost entirely of sodium, bicarbonate, and chloride. The actual chemical composition of a given closed lake will depend to a great extent upon the chemical character of the tributary waters.

Summary of Problems

Silvies River below Seneca

As shown in figure 111, bacterial levels of the Silvies River below Seneca are above safe limits recommended for water-contact recreation. These levels are the result of several raw sewage discharges from the community of Seneca.

Salinity Level in Lakes

Most of the lakes are too saline for any normal domestic or industrial use and are not large enough to make mineral recovery economically practical.

FUTURE WATER QUALITY MANAGEMENT NEEDS

Based on the projected economic development of the Oregon Closed Basin Subregion, the population is expected to increase from 13,300 in 1965 to 21,300 in 2020. This is an increase of 60 percent for the subregion compared with 121 percent for the region.

The projected populations for the years 1980, 2000, and 2020 are shown in table 160.

Table 160 - Projected Population, Subregion 12 (5) 1/

	1980	2000 (thousands)	2020
Total Subregion 1/	16.3	18.7	21.3
Municipal	6.9	9.5	12.5
Rural	9.4	9.2	8.8

1/ Differences between totals in this table and source are due to diffences in subregion boundaries. The source is based on economic boundaries and this table is based on hydrologic boundaries. The municipal population is defined as that population discharging wastes to a municipal sewerage system. The rural population is defined as the residual.

Future Waste Production

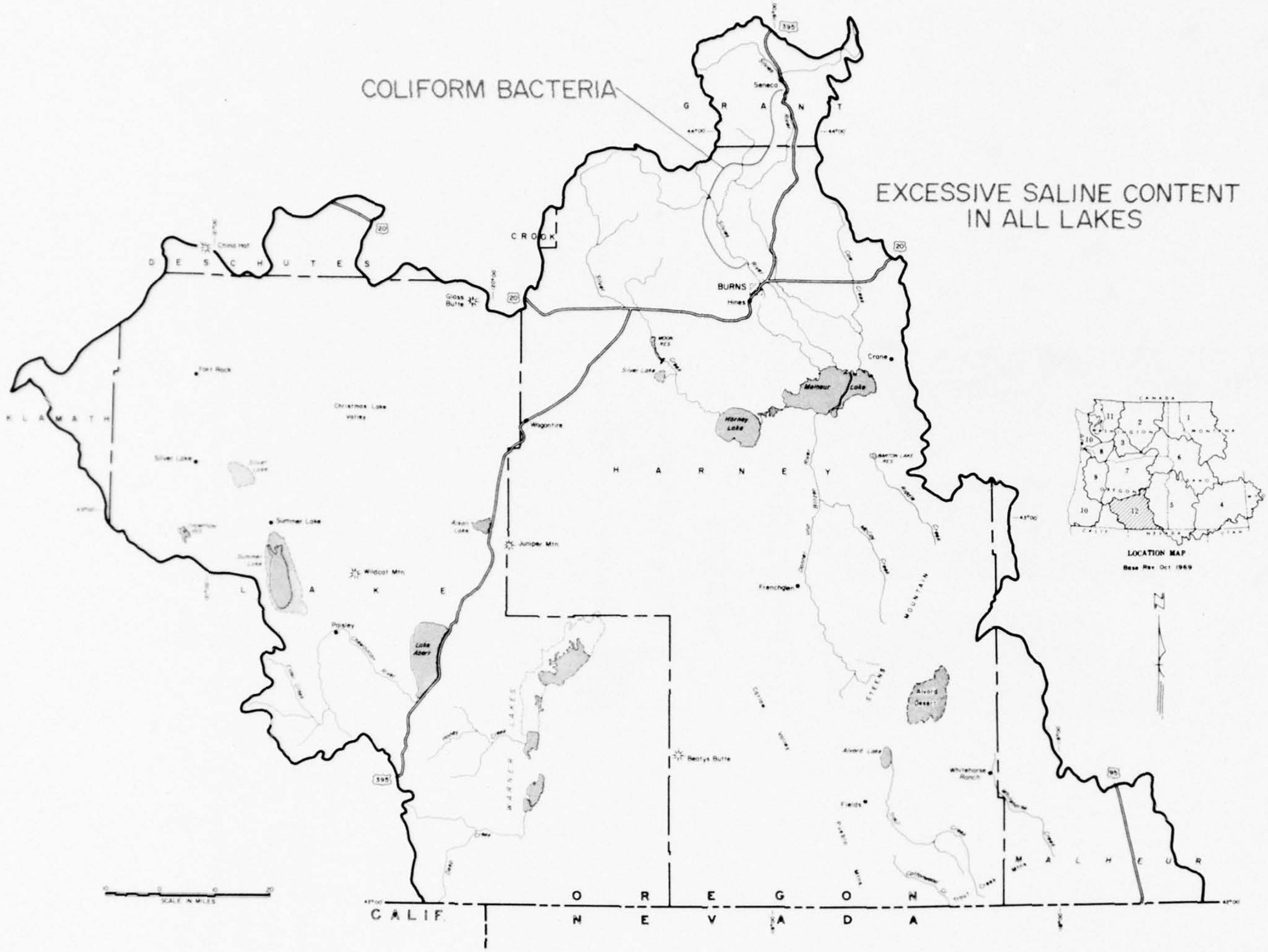
Municipal

The projected municipal raw waste production for the Oregon Closed Basin Subregion is presented in table 161. The population served by municipal waste collection systems is expected to increase from 42 percent in 1965 to 59 percent by the year 2020.

Table 161 - Projected Municipal Raw Organic Waste Production 1/
Subregion 12

	1970	1980	2000	2020
		(1,000's P.E.)		
Total Subregion	6.6	8.6	11.9	15.6

1/ A factor of 1.25 was applied to the municipal population components to account for the effects of small commercial establishments and other urban activities which add to municipal waste loads.



COLUMBIA–NORTH PACIFIC
COMPREHENSIVE FRAMEWORK STUDY

MAJOR WATER QUALITY PROBLEM AREAS

OREGON CLOSED BASIN
SUBREGION 12

1970

FIGURE III

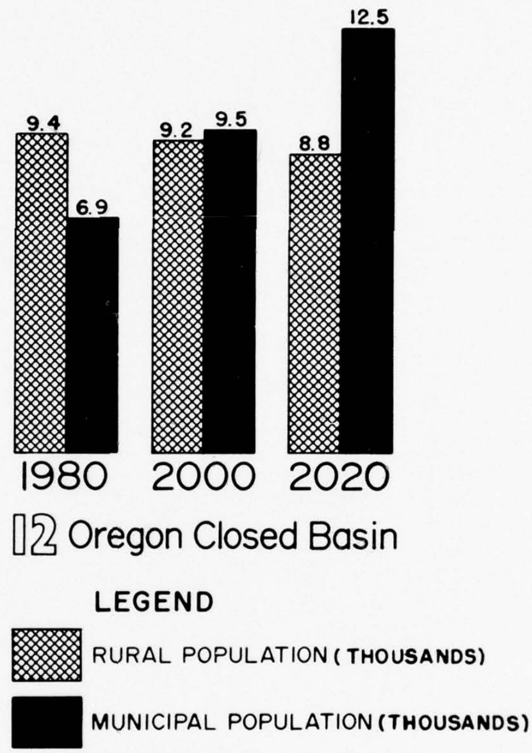


FIGURE 112. Projected Population, Subregion 12

Industrial

The industrial growth indices presented in table 162 show no significant growth for the lumber and wood products industry but shows food products, a very small industry, to more than quadruple by 2020. Since no data are available on the present production of raw organic waste, the projections for future waste production are not presented.

Table 162 - Industrial Growth Indices, Subregion 12 (17) (5)

	1980	2000	2020
Food Products	1.61	3.21	4.40
Lumber and Wood Products	1.04	1.04	1.07

It should be noted, however, that no significant change in industrial waste loading for the subregion is expected during the projection period.

Rural-Domestic

The projected rural-domestic waste production is presented in table 163 for the years 1980, 2000, and 2020. The rural-domestic waste production was assumed to be equal to the rural population component shown in table 160. The decrease of rural-domestic waste production is expected to be less than one percent by the year 2020.

Table 163 - Projected Rural Domestic Raw Organic Waste Production, Subregion 12

	1970	1980	2000	2020
		(1,000's P.E.)		
Total Subregion	9.0	9.4	9.2	8.8

Irrigation

In 1966, there were approximately 327,000 acres of land irrigated, which were supplied an annual diversion rate of two and one-third acre-feet per acre. Irrigated acreage is projected to increase to 330,000 acres by 1980, and to 340,000 acres by 2000, where it remains up to 2020.

Other Land Uses

Projections of land use in the subregion, by major types of land are shown in table 164.

Table 164 - Present and Projected Land Use, Subregion 12 (5) (8)

Land Use	1966	1980	2000	2020
		(thousands of acres)		
Cropland	365	363	361	352
Irrigated	(317)	(324)	(326)	(332)
Nonirrigated	(48)	(39)	(35)	(20)
Forest	1,893	1,874	1,842	1,805
Range 1/	8,733	8,726	8,741	8,767
Other 2/	404	413	424	436
Total	11,395	11,376	11,368	11,360

1/ Does not include forest range.
2/ Includes barren land, roads, railroads, small water areas, urban and industrial areas, farmsteads, airports, etc.

Agricultural Animals

The raw organic waste production by the livestock population in the subregion is expected to be equivalent to that from a population of 1,300,000 in 1980, 1,800,000 in 2000, and 2,300,000 in 2020. This would account for approximately 97 percent of the total raw organic waste production for the subregion. Most of this waste remains on the land, however, but rains and irrigation waters flush part of it into streams.

Recreation

The projected raw waste production by recreation activities in the subregion are summarized as follows:

Year	Population Equivalents 1/
1970	8,600
1980	11,000
2000	19,000
2020	34,500

In the determination of wastes from recreation activities, the population equivalent is based on the total annual recreation days. The values represent the daily raw waste production for a typical summer weekend. Excluding animal waste, the daily waste production from weekend recreation activities is approximately 54 percent of the total daily waste produced in the subregion during the recreation season.

1/Bureau of Outdoor Recreation and U.S.D.A. Forest Service Projections for total man recreation days (TMRD).

Table 164 - Present and Projected Land Use, Subregion 12 (5) (8)

Land Use	1966	1980	2000	2020
		(thousands of acres)		
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Irrigated	(317)	(324)	(326)	(332)
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1/ Does not include forest range.
2/ Includes barren land, roads, railroads, small water areas, urban and industrial areas, farmsteads, airports, etc.

Agricultural Animals

The raw organic waste production by the livestock population in the subregion is expected to be equivalent to that from a population of 1,300,000 in 1980, 1,800,000 in 2000, and 2,300,000 in 2020. This would account for approximately 97 percent of the total raw organic waste production for the subregion. Most of this waste remains on the land, however, but rains and irrigation waters flush part of it into streams.

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1/Bureau of Outdoor Recreation and U.S.D.A. Forest Service Projections for total man recreation days (TMRD).

Other Factors Influencing Quality

No other factors than natural are known to have an influence on water quality in the subregion.

Quality Goals

Water quality standards were adopted by the State of Oregon for the surface waters in the subregion. These standards are the basis for the water goals in this study.

In establishing the water quality standards, each stream was classified as to its intended use and criteria set to protect these uses through quality levels which must be maintained. The common parameters generally used are dissolved oxygen concentrations, temperature, turbidity, and coliform density. The water quality standards are summarized in table 165.

Table 165 - Water Quality Criteria, Subregion 12

Coliform	Not injurious to livestock watering, public health, etc.
Dissolved Oxygen	6 mg/1
Temperature	2°F. (1.1°C.) increase below 64°F. (17.7°C.)
pH	6.5-8.5
Turbidity	Not objectionable

The above uses and criteria are not inclusive and the water quality standards should be consulted for specific information. A copy of the water quality standards is available upon request from the Oregon State Department of Environmental Quality.

MEANS TO SATISFY DEMANDS

Preserving water quality in the Oregon Closed Basin is unique because of the limited amount of water and most of the waste water is disposed in lagoons and on the land. Although unique, the achievement and preservation of good water quality are based upon proper operation within the context of a political, social, and economic system.

Waste Treatment

For the purpose of this study, the treatment efficiencies assumed are: 85 percent removal for 1980 and 90 percent for 2000 and 2020. The projected municipal waste loadings shown in table 166 are based on the above treatment levels and raw waste projections presented earlier. The industrial organic raw waste production is considered to be insignificant.

Table 166 - Projected Municipal Organic Waste Discharge, Subregion 12

	1980	2000	2020
		(1,000's P.E.)	
Total Subregion	1.3	1.2	1.6

Treatment Costs

Curves showing estimated costs of constructing (total capital) and operating (annual operation and maintenance) municipal sewage treatment plants for various treatment levels are presented in the "Means to Satisfy Demands" section of the Regional Summary.

Other Pollution Control Practices

Flood irrigation is used extensively in the subregion and results in high sediment and silt loads during the irrigation season. More efficient irrigation practices are needed in the subregion.

Recreation areas will be increasing in numbers, size, and intensity in the subregion. Sewage disposal and facilities for the collection and pickup of litter and garbage must be provided.

Minimum Flow Requirements

Inasmuch as most of the municipal and industrial waste is disposed on the land, minimum flow requirements for these wastes will be negligible. Minimum flows are necessary to assimilate the waste from irrigation return flows, agricultural waste water and other nonpoint sources. In addition, a variety of chemical substances are applied to the land for such purposes as insect and weed control which finds its way into the streams.

Management Practices

The State occupies a strategic position in water quality management. It has the major responsibility for pollution control by requiring the adequate treatment of all waste discharges.

Stronger land use controls and other controls must be developed that: (1) give significant attention to the physical capabilities of the water, and (2) give protection to the various uses of water. The water resources are presently limited in the subregion and require careful management of the available supplies.

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GLOSSARY

ACRE-FOOT - 43,560 cubic feet or 325,829 gallons.

AQUIFER - A geologic formation that is water-bearing and that transmits water from one point to another.

BASIN - A geographic area drained by a single major stream.

BOD (BIOCHEMICAL OXYGEN DEMAND) - The quantity of oxygen utilized in the biochemical oxidation of organic matter in a specified time and at a specified temperature. It is not related to the oxygen requirements in chemical combustion, but is determined entirely by the availability of the material as a biological food and by the amount of oxygen utilized by the microorganisms during oxidation.

CFS (Cubic Foot per Second) - A unit of discharge for measurement of flowing liquid equal to a flow of one cubic foot per second past a given section. Also called second-foot.

COD (CHEMICAL OXYGEN DEMAND) - The quantity of oxygen utilized in the chemical oxidation of organic matter. It is a measure of the amount of such matter present.

CHLORINATION - The application of chlorine to water, sewage, or industrial wastes generally for the purpose of disinfection, but frequently for accomplishing other biological or chemical results.

COLIFORM BACTERIA - A species of genus escherichia coli bacteria, normal inhabitant of the intestine of man and all vertebrates.

COLUMBIA-NORTH PACIFIC REGION - The geographic area including all of the Columbia River Basin in the United States, the closed basin portion of Oregon, and all of the coastal streams of Oregon and Washington.

COMPLETE TREATMENT - Coagulation, sedimentation, filtration, and disinfection.

CURIE - A unit quantity of any radioactive species in which 3.7×10^{10} disintegrations occur per second.

DO (DISSOLVED OXYGEN) - The oxygen dissolved in sewage water or other liquid, usually expressed in milligrams per liter or percent of saturation.

EFFLUENT - Sewage, water, or other liquid which is partially or completely treated or in its natural state, as the case may be, flowing out of a reservoir, basin, or treatment plant or part thereof.

EUTROPHICATION - The process of overfertilization of a body of water by nutrients which produce more organic matter than the self-purification processes can overcome.

f (Self-purification factor) - the self-purification factor is an indication of the ability of a stream to assimilate a waste discharge. It is defined as the ratio or reaeration (r) and the rate of deoxygenation (k): rate of self-purification = $r/k = f$ where f is called the self-purification factor.

GPD - Gallons per day.

GPCD - Gallons per capita per day.

HARDNESS - A characteristic of water; chiefly due to the existence therein of the carbonates and sulfates and occasionally nitrates and chlorides of calcium, iron, and magnesium; which causes "curdling" of the water when soap is used, increased consumption of soap, deposition of scale in boilers, injurious effects in some industrial processes, and sometimes objectionable taste in the water. It is commonly computed from the amounts of calcium and magnesium in the water and expressed as equivalent calcium carbonate.

HYDROGEN ION CONCENTRATION - The weight of hydrogen ions in grams per liter solution. Commonly expressed as the pH value that represents the logarithm of the reciprocal of the hydrogen ion concentration.

JTU (JACKSON TURBIDITY UNIT) - The JTU is a measurement of the turbidity, or lack of transparency, of water. It is measured by lighting a candle under a cylindrical transparent glass tube and pouring a sample of water into the tube until an observer looking from the top of the tube cannot see the image of the candle flame. The number of JTU's varies inversely with the height of the sample (e.g. a sample which measures 2.3 cm has a turbidity of 1,000 JTU's whereas a sample measuring 72.9 cm has a turbidity of 25 JTU's).

MGD (Millions of Gallons per Day) - A flow of one mgd for one year equals 112 acre-feet. Also, one mgd equals 1.597 cfs.

MG/L - Milligrams per liter.

MPN (Most probable number) - In the testing of bacterial density by the dilution method, that number of organisms per unit volume which, in accordance with statistical theory, would be more likely than any other possible number to yield the observed test result or which would yield the observed test result with the greatest frequency. Expressed as density of organisms per 100 ml.

MAJOR SERVICE AREA - Arbitrarily selected service areas containing significant portions of the region's population and industry--(e.g. Seattle, Tacoma, Everett, Portland, Salem, Eugene-Springfield, Spokane.)

OBE - Office of Business Economics.

PE - (POPULATION EQUIVALENT) - The measure of the strength of a waste effluent converted to an equivalent number of people which would be required to produce the same biochemical oxygen demand in one day. One PE is 0.16 of a pound per day of biochemical oxygen demand as exerted by the wastes from one person.

PICOCURIE - 10^{-12} curies.

pH - See Hydrogen ion concentration.

POLLUTION - Pollution is the alteration of the physical, chemical, or biological properties of water, or a discharge of any substance into water, which adversely affects any legitimate beneficial water use.

PRIMARY WASTE TREATMENT - The removal of settleable, suspended, and floatable solids from waste water by the application of mechanical and/or gravitational forces. In primary treatment, unit processes such as sedimentation, flotation, screening, centrifugal action, vacuum filtration, dissolved air flotation, and others designed to remove settleable, suspended, and floating solids have been used. Generally, a reduction in dissolved or colloidal solids has been obtained in primary treatment, but this effect is incidental and not the planned purpose of primary treatment.

RUNOFF - That part of rainfall or other precipitation that reaches water-courses or drainage systems.

SALINITY - The relative concentration of salts, usually sodium chloride, in a given water sample. It is usually expressed in terms of the number of parts per thousand of chlorine (Cl).

TERTIARY OR ADVANCED WASTE TREATMENT - Selective application of biological, physical, and chemical separation processes to effect removal of organic and inorganic substances that resist conventional treatment practices.

TURBIDITY - (1) A condition of a liquid due to fine visible material in suspension which may not be of sufficient size to be seen as individual particles by the naked eye, but which prevents the passage of light through the liquid. (2) A measure of fine suspended matter (usually colloidal) in liquids.

TYPE 1 STUDY - Framework studies and assessment (Type 1 Studies) are the evaluation or appraisal on a broad basis of the needs and desires of people for the conservation, development, and utilization of water and land resources and will identify regions or basins with complex problems which require more detailed investigations and analysis, and may recommend specific implementation plans and programs in areas not requiring further study. They will consider Federal, State, and local means and will be multiobjective in nature.

TYPE 2 STUDY - Regional or river basin studies (Type 2 Studies) are reconnaissance-level evaluations of water and land resources for a selected area. They are prepared to resolve complex long-range problems identified by framework studies and assessments and will vary widely in scope and detail; will focus on middle term (15 to 25 years) needs and desires; will involve Federal, State, and local interests in plan formulation; and will identify and recommend action plans and programs to be pursued by individual Federal, State, and local entities. They will be multiobjective in nature.

S.A.R. (Sodium Adsorption Ratio) - A ratio for soil extracts and irrigation waters used to express the relative activity of sodium ions in exchange reactions with soil.

SECONDARY WASTE TREATMENT - The removal of dissolved and colloidal materials that in their unaltered state, as found in waste water, are not amenable to separation through the application of primary treatment. Secondary treatment is generally accomplished through unit processes such as bioabsorption, biological oxidation, wet combustion, other chemical reactions, adsorption on surface-active media, change of phase, or other processes that result in the removal of colloidal and dissolved solids from waste waters.

SEDIMENT - (1) Any material carried in suspension by water which will ultimately settle to the bottom after the water loses velocity. (2) Fine water-borne matter deposited or accumulated in beds.

SERVICE AREA - A service area is an area described for planning purposes whose boundaries include the future population or industrial activities which could logically and functionally obtain its water supply and waste disposal services from a central or integrated system, or where the problems are so interrelated that the planning should be done on an integrated basis.

SUBBASIN - A portion of a subregion or basin drained by a single stream or group of minor streams.

SUBREGION - The subdivisions of a region defined along drainage basin boundaries for study and report purposes. The Columbia-North Pacific Region's subregions are:

1. Clark Fork-Kootenai-Spokane
2. Upper Columbia
3. Yakima
4. Upper Snake
5. Central Snake
6. Lower Snake
7. Mid Columbia
8. Lower Columbia
9. Willamette
10. Coastal
11. Puget Sound
12. Oregon Closed Basin

TDS - Total dissolved solids.

PARTICIPATING STATES AND AGENCIES

STATES

Idaho	Nevada	Utah	Wyoming
Montana	Oregon	Washington	

FEDERAL AGENCIES

Department of Agriculture
- Economic Research Service
- Forest Service
- Soil Conservation Service

Department of the Army
- Corps of Engineers

Department of Commerce
- Economic Development Adm.
- National Oceanic & Atmospheric Administration
  - National Weather Service
  - National Marine Fisheries Service

Department of Health, Education, & Welfare
- Public Health Service

Department of Housing & Urban Development

Department of Transportation

Department of the Interior
- Bonneville Power Adm.
- Bureau of Indian Affairs
- Bureau of Land Management
- Bureau of Mines
- Bureau of Outdoor Recreation
- Bureau of Reclamation
- Fish and Wildlife Service
- Geological Survey
- National Park Service

Department of Labor

Environmental Protection Agency

Federal Power Commission